JULY, 1941

ORGANIC FINISHING

SECTION OF METAL FINISHING

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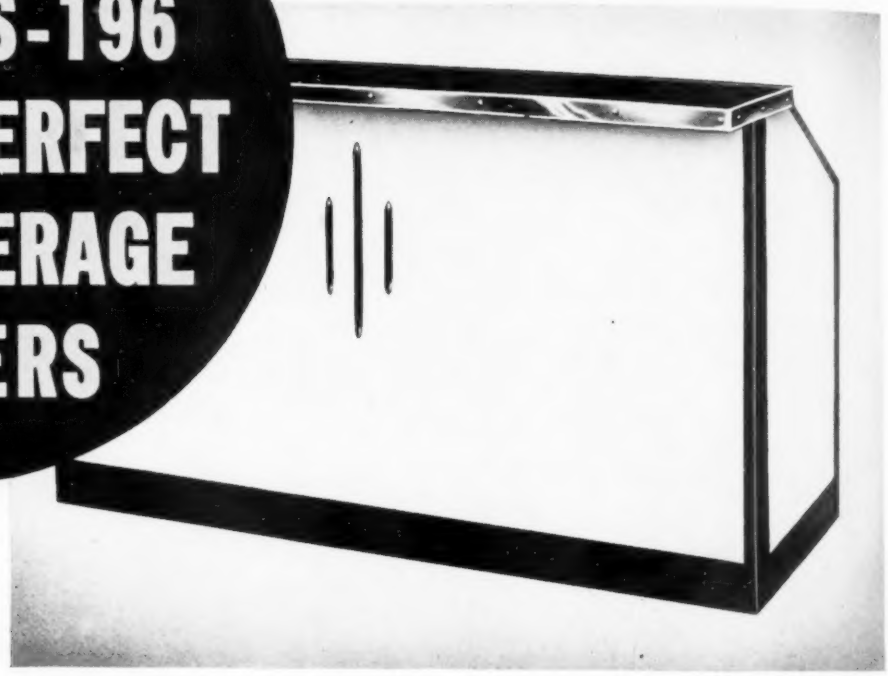
duranite *Today's Finish For Today's Products*

DURANITE WHITE S-196 PROVES PERFECT FOR BEVERAGE COOLERS



Zapon Duranite White S-196 is maintaining its reputation for standing up in hard service as well as giving a beautiful, glossy finish. Illustrated is a dry storage beverage cooler, made by the Victor Products Corp., of Hagerstown, Md., one of this Duranite's many users.

S-196 covers solid over 1 coat of 4000-A white primer with no shadows, using one flash pass followed by a solid pass. The resulting porcelain-like finish is approximately 1½ mils. in thickness. Baking schedules are a matter of minutes.

The black trim on the cooler shown is also a Duranite, which stands up equally as well as the white. From refrigerators to clock dials, there are suitable variations of Duranite available.

DURANITE—Trade Mark

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ZAPON DIVISION · ATLAS POWDER COMPANY

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JULY, 1941

CONTENTS

ARTICLES

DEPARTMENTS

Picture on Cover

Photograph of down-draft spray booth where large bed castings are filled, sanded and prime coated.

(Courtesy Gisholt Machine Co., Madison, Wis.)

Large Increase in Consumption of Finishing Materials

According to a recent report of the Bureau of Census, compiled from the records of 680 establishments, the value of finishing materials sold during the first four months of 1941 was approximately 36 millions of dollars greater than that of the same period of last year. This is an increase of approximately twenty-nine per cent.

These figures do not tell the whole story, however. Data on the individual months show an increase of approximately 6 millions of dollars (twenty-one per cent) for January, seven millions of dollars (twenty-seven per cent) for February, eight and one half millions of dollars (twenty-seven per cent) for March, and more than fourteen millions of dollars (thirty-eight per cent) for April.

These are astounding data. They indicate that, already in 1941, enough finishing materials have been sold to cover, by very conservative calculation, more than one billion more square feet of wood, metal, plastics, fabrics, etc. than were finished in 1940. They indicate that already, and again by conservative calculation, more than a quarter of a million more man-hours than were required in 1940 will be required this year. Finally, they indicate the necessity for more finishing equipment, more cleaning equipment and supplies, more conveyors, more of everything involved in the application of organic finishes.

This tremendous expansion means that a terrific burden is being placed on the finishing industry—on engineers, finishing superintendents, and the finishers and painters themselves. Any finishing operation requires time and thought in order to make it efficient and produce the quality of work required. Fortunately, the finishing industry has not been decadent in the past years and many plans and ideas, worked out in the relative leisure of normal production, are now ready to be put into use, quickly and effectively. Yes, the burden is a heavy one but it is our opinion that the finishing industry will assume it and handle it with a minimum of difficulty and a maximum of efficiency.

L. H. LANGDON, *Publisher* • T. A. TRUMBOUR, *Business Manager* • DR. WALTER R. MEYER, *Editor*

The Uses and Limitations of Radiant Heat for Baking Organic Finishes*

By G. KLINKENSTEIN

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Introduction

THE first commercial application of the infra-red baking process was developed in the works of the Ford Motor Company about eight years ago. This company controls patents covering this process and permits their use without restrictions. This liberal attitude deserves the gratitude of everyone in the industrial finishing business. For several years, the use of infra-red baking was almost entirely restricted to automobile finishing, but because the process of baking organic finishes by means of short infra-red rays was found to be highly economical for other kinds of work, its use spread widely in the industrial finishing field during the last year.

As is often the case with new developments, the special advantages and limitations of this process were not at first fully understood. As a result, some of its applications proved unsatisfactory.

Similar errors need no longer be made. We now know enough about infra-red baking to evaluate its possibilities correctly and to avoid applying it where its use will not be profitable.

Infra-red heat is commonly supplied by electric lamps, but there are other sources of infra-red radiation. Vitreous grilles, heated to incandescence by gas flames, are used for certain baking operations, but such heaters are not suitable for baking organic finishes because of the fire hazards involved.

The infra-red lamps are usually arranged to form tunnels through which the products to be baked are carried by conveyor systems, but portable banks of lamps are used to bake finishes on products too bulky to be handled by conveyors, and individual portable lamps are used for touch-up work.

The rays that do most of the work of baking in the infra-red process are those that lie close to the visible red rays in the spectrum. Strictly speaking, the term "near infra-red" should be applied to these rays to distinguish them from the "far infra-red" rays given off by the sources of heat used in convection ovens. As no real confusion results however, the simpler term "infra-red" has come into general use. The term "infra-red" heat is now being commonly replaced by the more descriptive term, "radiant heat," which will be used throughout this paper.

Organic finishes are baked by means of radiant heat when they are exposed to the rays emitted by specially designed electric lamps, equipped with reflectors to localize the radiation at the finished surfaces. These lamps are mounted on a skeleton framework to make easy adjustment or focusing of the radiant-heat rays.

Gustave Klinkenstein

When these rays strike a freshly applied finish, the finish film becomes hot and its temperature is raised to the baking temperature within one or two minutes. This is in strong contrast with the action that takes place in the ordinary convection type of oven, where first the air must be heated, and then the entire mass of the products on which a finish is being baked gradually absorbs the heat until baking temperature is reached. It may be fifteen or twenty minutes before the mass of products and the hot air in the oven reach equilibrium.

Speaking in physical terms, the visible light rays from violet to red, have wave-lengths lying between 4000 and 7800 Angstrom units; those we are calling the infra-red rays have wave-lengths between 7800 and 14,000 Angstrom units; and the far-red rays have wave-lengths running up to 120,000 Angstrom units.

Radiant-heat baking is not necessarily limited to the infra-red rays. Certain types of lamps, using enclosed reflectors, utilize a band ranging from 7500 to 30,000 Angstrom units.

Radiation lying on the other side of the visible spectrum may also in time play a part in the treatment of organic finishes. John Sanderson, of the American Cyanamid & Chemical Corporation, has published the results of experiments indicating that ultra-violet radiation may also be useful in accelerating the hardening of certain types of finishes. If further research shows that this work has a practical side, the organic finisher may find use for other radiating devices. However, this further development lies well within the future.

It is fair to say that most industrial finishers believe that the radiant heat

*Presented at Annual Convention of American Electroplaters' Society, Boston, Mass., June 11, 1940.

Fig. 1. **Master oven in Customers' Service Laboratory of C. M. Hall Lamp Co., Detroit, Mich. showing some of the equipment used to determine just what size oven is necessary for a customer's particular job. Transformers are used for varying heat densities and a potentiometer for measuring temperature.**

rays possess special heating properties and that the radiant-heat baking process differs in principle from the process of baking in an ordinary convection oven. Specifically, it is commonly held that, in a convection oven, the finish is baked from the outside inwards, whereas, with radiant heat baking, the rays pass through the coat of finish, heat the underlying material, and thus bake the finish from the inside outwards.

This idea is not correct. As a matter of fact, the radiant heat process is generally used for baking opaque finishes which the rays can not penetrate. We are, therefore, dealing, not with a new kind of heat, but merely with a new and very rapid method of applying heat.

In other words, the radiant heat process is just one more form of baking. It provides the industrial finisher with another tool but not one of unlimited usefulness. It gives excellent results with certain kinds of work, but it is inefficient as compared with the convection oven for other applications, and, for some important purposes it is useless. It is by no means going to supersede the convection oven completely.

As practical finishers, we are chiefly concerned with ascertaining under what conditions radiant heat baking should and should not be used. Let us give this subject careful consideration.

Conditions for the Efficient Use of Radiant Heat Baking

The cost of electric current must be low.—Comparative cost studies indicate that radiant heat baking cannot ordinarily compete on an energy cost with baking by oil or gas heat unless the electric current can be purchased for $1\frac{1}{4}$c per kilowatt-hour, or less. In certain cases, however, some of the special advantages of radiant heat baking may out-weigh higher operating costs.

The heating equipment must be specifically designed for the work it is to do.—In order to produce a satisfactory finish and to keep operating expenses low, a radiant heat baking installation must be designed for the particular product and the particular finish it is to handle.

For a well-baked finish, the entire coating must be heated evenly to the required temperature. This is accomplished by locating the lamps so that they irradiate all finished areas on the product uniformly from an accurately determined distance.

With products of simple form, such as sheets, rectangles, and cylinders, it is an easy matter to arrange the lamps in the proper manner, but when the product is irregular in shape, a complicated set-up may be required in order to avoid the formation of hot or cold spots. With very irregular products, such as those with knobs or deep recesses, it may be impossible to use radiant heat baking.

The radiant energy must be used efficiently—Efficient operation is important because, even with cheap electricity, the electric lamp is an expensive source of heat, and if much of the energy it radiates is wasted, the cost of current may become prohibitive.

The energy emitted by the lamps may be wasted in the following ways:

The radiation may not strike the work.
It may be reflected from the surface of the work.
It may be carried away, through convection, by air currents.
It may be re-radiated from the work when the latter reaches an elevated temperature.

To keep these losses at a minimum, the heating installation must be carefully planned, with every factor affecting current consumption taken into consideration.

Radiant heat baking is best suited to the quantity production of similar products.—When a radiant heat oven using open reflectors is set up to bake a given product, it cannot handle products that differ greatly in size or shape. A cylindrical oven has more latitude in this respect, but the variety of products that can be baked in it is not unlimited.

The oven can be re-arranged at any time to fit the requirements of another product, but such changes require careful study on the part of experienced men and can not be made frequently without delaying production and greatly increasing costs.

In consequence, radiant heat baking using open reflectors is not suitable for the use of manufacturers who must bake many different kinds of products at the same time or are constantly changing the character of their output. It is essentially a tool for use in the mass production of single, or similar, products.

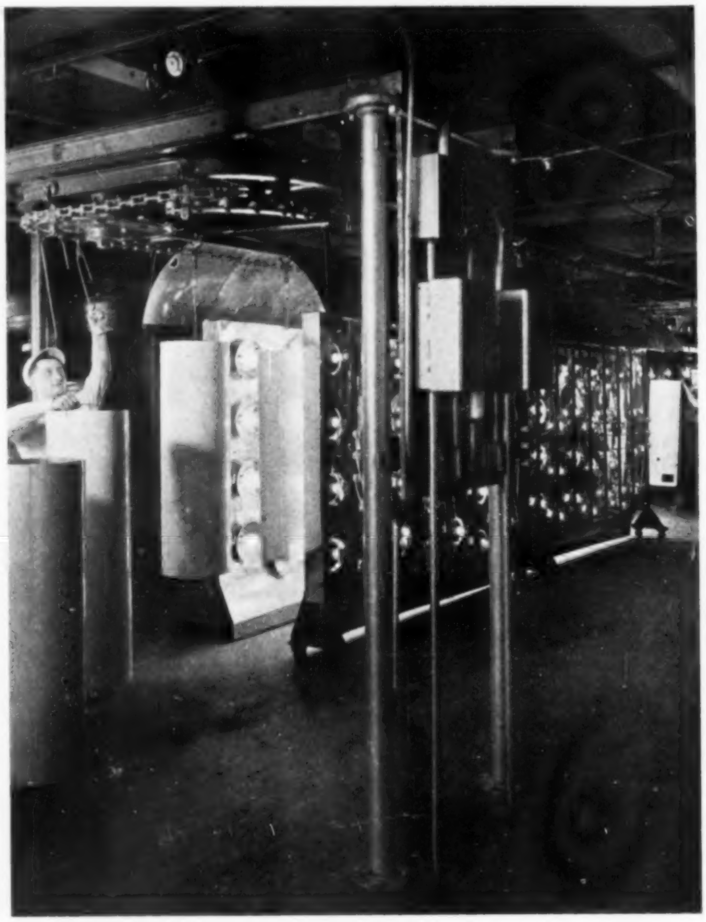

Fig. 2. Radiant heat installation for baking enamel on hot water heater bodies. The process is stated to have reduced operating costs 25% and increased production 85%.

(Courtesy, The Fostoria Pressed Steel Corp., Fostoria, Ohio)

Metal products usually can be baked by the radiant heat process.—Wood products can be baked in radiant heat ovens, but unless the greatest care is taken, bubbling or pin-holing will occur, due to the gases and moisture contained in the cells of the material. For all practical purposes, the use of radiant heat baking has been confined to metal products.

The finish used must be suitable for radiant heat baking.—Only those finishes which are hardened solely by the application of heat can be baked efficiently in radiant heat ovens. Fortunately, these "heat-reactive" finishes are the ones favored for use in high-speed mass production so that they suit the usual applications of the process.

Radiant heat baking is inefficient as compared with convection-oven baking when used for finishes that must be baked for a long period of time, such as the finishes that harden by oxidation and the japans.

It is also inefficient for baking clear finishes on polished metal surfaces because a large percentage of the radiation is wasted by reflection. But when the clear finish is applied over a non-reflecting surface or a pigmented undercoat, this difficulty is not as serious.

The heat from the infra-red lamps tends to slightly "char," or turn yellow, certain types of finishes, so that these must be avoided when the process is used.

On the other hand, certain enamels, that when baked in convection ovens, are apt to wrinkle on fatty edges or when applied too heavily, are baked without trouble in radiant heat ovens.

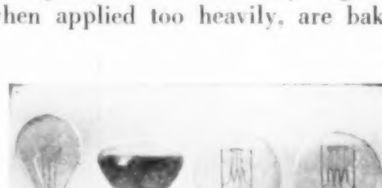

Fig. 3. Some types of heat lamps made by Westinghouse Electric Mfg.

The finishes used in radiant heat baking should be specially formulated in order to secure best results.—Not only should the kinds of finishes used in radiant heat baking be carefully selected, but those employed should be specially formulated to suit the requirements of the process. This subject will be discussed more fully later.

Baking temperatures above 600° F. can not be obtained with radiant heat baking.—This limitation is important for certain baking processes, such as vitreous-enamel baking, but no organic finishes require baking temperatures beyond the range of this process.

The Advantages of Radiant Heat Baking

From the standpoint of production—When radiant heat baking is carried on under proper conditions, it possesses the following physical and economic advantages, as compared with convection-oven baking:

1. Since the surface to be baked heats up to baking temperature almost immediately under the impact of the radiant-heat rays, and high energy-densities can be employed, if desired, there is no long preliminary heating up period. In consequence, baking operations that require an hour in a convection oven are commonly accomplished in less than 10 minutes by the radiant-heat process. Lacquers can be dried dust-free in 10 minutes.

2. The radiant-heat process is admirably adapted for baking work handled by conveyors so that it is especially suited for high-speed mass production.

3. Radiant-heat baking equipment is simple, light in weight, and highly flexible. It can be installed at almost any point on the conveyor line where there is sufficient length of travel and can be removed and replaced elsewhere at will. The lamp racks can be mounted on the floor, suspended from the ceiling, or attached to walls.

4. The space required by a given radiant heat installation averages about one-third, and maybe as little as one-tenth, of that required by a corresponding convection oven.

5. The cost of installation is low. No insulating walls, doors, or automatic temperature controls are required.

6. Maintenance costs are low. Lamps are the only parts that need regular renewal, and these last from 5,000 to 10,000 hours or more. The

installation needs no special care beyond cleaning lamps and reflectors about once a month, if open reflectors are used, or merely cleaning the lenses if sealed reflectors are used.

7. If the equipment is properly installed and maintained, there is little danger of fire or explosion.

8. Working conditions are comfortable because a radiant heat oven does not raise the temperature of the surrounding air to high temperatures. On standing directly behind the lamps, one has little sensation of heat.

From the standpoint of finishing—The industrial finisher favors radiant heat baking, where it is applicable, for the following reasons:

1. Since the whole operation is visible, every step in the baking process can be carefully controlled.

2. By arranging the lamps so that they illuminate the work evenly, without shadows or over-illuminated spots, uniform baking is assured.

3. Conversely, the heat can be directed and confined to any desired zone or arranged in any desired pattern, thus permitting special baking effects and utilizing the radiated energy with high efficiency.

4. If the finish is being improperly baked at any point, the trouble can be immediately detected and corrected, thus reducing spoilage.

5. Baking conditions, when once set, will be rigidly maintained, if voltage, speed of travel of the products, and air conditions are kept constant and the equipment is properly maintained at all times.

6. Large surfaces, which must be baked vertically, are best baked in radiant-heat ovens, because the entire surface can be heated uniformly, whereas in convection ovens, it may be difficult to secure uniform heating due to the presence of heat zones.

7. Coatings on massive products, if properly selected, can be baked quickly in radiant-heat ovens, since it is not necessary to bring the entire product up to baking temperatures.

8. "Case hardening" does not occur; that is, no surface film, which interferes with the escape of the solvent, forms on the coating.

9. There is less danger of "chilling," which may cause wrinkling, crystallization, or loss of gloss.

10. Under proper supervision, changes of finishing schedules are easily made.

Finishes for Use with Radiant Heat Baking

In any organic finishing operation it is important to select the finish to suit the product, the finishing process, and the service to which the product is to be subjected, but when radiant-heat baking is employed, the finish must be selected with special care. The longer the time required to bake a finish by the radiant heat process, the greater will be both the amount of heating equipment required and the cost of the current consumed. Hence, for the sake of both speed and economy, the finish selected should always be one that will produce the desired results with shortest baking period.

Several unusual problems are encountered in formulating finishes for radiant heat baking. For example, blacks heat up rapidly under radiant heat rays because they absorb the radiation almost completely; whites, however, heat up more slowly because they reflect a large part of the rays; and other colors occupy intermediate positions between these two extremes.

Theoretically, it is possible to compensate for these differences by varying the setting of the lamps or increasing or decreasing the wattage, but in practice, it is much more satisfactory to change the finish so that similar products can be baked in the same oven regardless of their color.

Again, solid products, especially those in the form of rods or spheres, heat up much more slowly than sheet metal products under radiant heat because the heat applied to the surface is conducted away by the mass of metal in the interior. If the same finish is used on both kinds of products, it will be necessary to reduce the speed with which the solid products travel through the oven or to increase the length of the oven, but by using different types of finishes, both kinds of products can be baked with equal speed.

Wrinkle enamels offer a special problem. Enamels of this type, as formulated for convection-oven baking, tend to flatten out under radiant-heat rays. Hence, wrinkle enamels for radiant heat baking should be specially formulated.

In general, close cooperation between the user of the finish and the finish manufacturer is essential if the best results are to be secured with radiant-heat baking.

When a radiant-heat baking installation is first set up, it can be assumed that it will operate efficiently with the finish to be baked by it. But unless

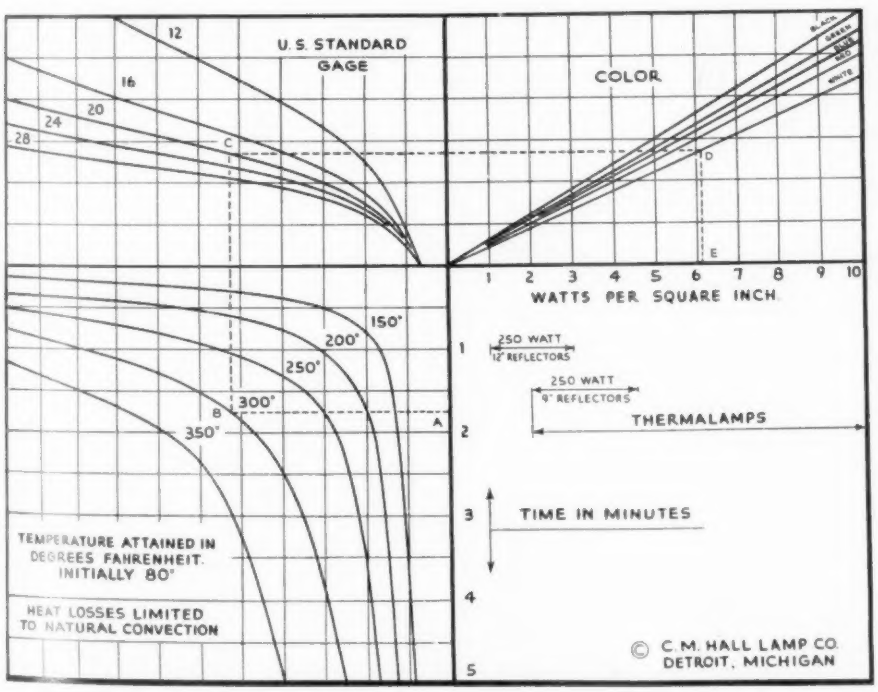

Fig. 4. Performance chart for radiant heating.

The chart is workable both ways (A) At a given time in minutes and knowing the degree of temperature to be used and the gauge of metal being baked, and the color of synthetic enamel being baked, the watts per square inch input necessary are disclosed. (B) On the other hand, if the watts per square inch input from radiant heat equipment are known, then by tracing an imaginary line up to the color of synthetic enamel, over to the gauge of metal, down to the temperature necessary, the line can be extended over to the minutes required to bake the paint. (Courtesy, C. M. Hall Lamp Co., Detroit, Mich.)

this finish was expertly selected in the first place, a more efficient one might be substituted for it, so that it is always wise to check this point.

When the work for which the oven was designed is completed and changes are to be made in either the product or the finish, the finish manufacturer should always be consulted, since he can supply the type of finish best suited to the particular conditions under which the oven is going to operate.

Installation and Operation

Without attempting to cover the engineering features of a radiant-heat baking installation with any degree of completeness, the following details are mentioned because they are of special interest to the user of the equipment.

Special radiant-heat baking lamps, which emit more than 90% of their energy input in the form of radiant-heat rays, are supplied in 250, 500, 1000 watt sizes. All sizes are supplied with separate reflectors, and the 250-watt size is also supplied with self-contained reflectors.

Gold-plated reflectors, though not especially efficient as reflectors of visible light rays, reflect 98 per cent of the radiant heat. Oxidized aluminum reflectors, which reflect from 75 to 91 per cent of the radiant heat, are also used. Silver, when bright, is a highly efficient reflector, but it is impractical because it tarnishes easily.

A new coating for reflectors that is coming into use is vaporized aluminum. It is said to have a high degree of permanence, ability to withstand oven temperatures, and a reflectivity that is estimated to be 20% higher than gold over mean life conditions.

Open reflectors are round or hexagonal (interlocking), and can usually be adjusted so that the rays emitted by the lamps will be convergent, divergent, or parallel, as required.

Lenses are now being used to give better heat distribution and avoid hot spots, and reflectors of special designs are also employed for the same purpose. These new types of sealed lenses and reflectors with 1000-watt lamps have increased the usefulness and scope of radiant-heat baking.

They are supplied mounted individually, or in multiple reflector strips, flexible tunnels, and flat banks. As the separate sealed lamps thus mounted have a considerable range of adjustment, ovens of almost any description can be built up of these units. They can be designed to combine radiant heating with convection heating by suitable enclosures.

When 250-watt lamps are used, they must be placed within 8 to 14 inches of the surfaces to be baked. Best results are generally secured when the distance from lamps to work is between 10 and 12 inches. Using 1000-watt lamps enclosed by special new reflectors and lenses, it has been possible to increase the distance from the lamps to the work up to 18 inches. The work must be fully and evenly illuminated, with no part to be baked in a shadow. The basic problem with radiant-heat baking is, in fact, to place the lamp correctly.

With the lamps properly placed, the energy requirements of the process are from 2 to 10 watts per square inch, or from about 300 to 1500 watts per square foot.

Twenty-gauge sheet steel, painted black, is heated in 5 minutes to 280° F. by 2 watts per square inch, and to 500° F. by 6 watts per square inch. When heavier gauge steel or lighter colors are used, the temperatures are somewhat less for the given time and wattages.

The greater the wattage per square inch, the quicker the desired temperature is attained and the greater the efficiency of the process. For this reason, it is frequent practice to expose the work to an excessive wattage at the entrance to the oven, so as to raise it quickly to baking temperature; this temperature is then maintained in the body of the oven with a lower wattage.

Radiant heaters are also sometimes placed in front of convection ovens, so as to raise the temperature of the work quickly without danger of damaging the finish through pimpling, cratering or wrinkling, which might occur under like conditions in a convection oven.

Cylindrical or elliptical ovens, with open-reflector lamps, are used for baking products that are finished over-all and are not too irregular in shape. These ovens are efficient because they minimize shadows, cold spots, and upward drafts. Two parallel flat banks of lamps are used for baking sheets and other flat objects. Special arrangements often have to be made to bake products of irregular shape or larger dimensions. Sheet metal coated on one side is best baked by heating the unfinished side.

When lamps with closed reflectors are used, the oven should be enclosed in a sheet-iron casing, and, for general purposes, its cross-section should be a rectangle with rounded corners.

Drafts retard baking and decrease the efficiency of the process, but some ventilation through the oven is required to remove the solvent vapors. The natural ventilation caused by air currents heated by the hot work is usually sufficient for vapor disposal and does not seriously interfere with the operation of the oven. In special cases, draft shields and exhaust hoods may be needed to remove excessive amounts of solvents.

When products pass through an oven at intervals, current can be saved by the use of automatic switches which turn on the lamps in front of each piece as it travels through the oven and turn off the lamps after it passes.

When using open reflectors, the reflectors and lamps in the lower portions of the oven tend to become covered with a film of finishing materials, which decreases their reflectivity. All types of reflectors can be cleaned by wiping them off with cotton bat dipped in the proper type of thinner to dissolve the film of finish. Gold-plated reflectors can be cleaned more thoroughly by dipping them into a solution of caustic soda, or into a solution of 2 oz. trisodium phosphate to a gallon of water followed by a dip in 4% hydrochloric acid. After using either of these methods, rinse and polish lightly.

Fire Safety Precautions for Radiant Heat Ovens

All electrical equipment must be installed in accordance with the National Electric Code. For greatest safety, lamps should be enclosed.

Ovens should be cut off by approved means from dipping and spraying rooms. They should not be set up in small rooms without good ventilation.

Ventilating hoods should be used where an excessive amount of solvents or flammable dust is given off.

Products carried by the conveyors must be so mounted that they do not cause lamp breakage or short circuits.

Lamps and equipment should be kept clean and free from deposits of flammable finishing materials.

The conveyor should be equipped with automatic control so that the lamps will be cut off if it stops; or if a conveyor is not used, a time-switch

should limit the total time of exposure of products to the heat.

Sprinkler protection is desirable, and when used, the radiant heat equipment should be so arranged that it does not interfere with the spray from the sprinklers. Ordinary sprinkler heads can be employed, as the air above the oven is not heated to unusually high temperatures. An ample number of vaporizing-liquid, foam, or carbon dioxide portable fire extinguishers should be quickly available, and all workers in the finishing department should know how to use them.

Conclusion

Many people have contributed to our understanding of this important addition to the facilities of the industrial finisher, and I am indebted to others for much of what I have to say today. The accompanying bibliography lists those who have published important articles on this subject, but much credit is also due to unrecorded workers in the industrial finishing field.

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"Putting the Heat on White Enamels," John McE. Sanderson, Am. Cyanamid & Chem. Corp., *Organic Finishing*, Oct. 1940.

Organic Finishing Digest

Corrosion Prevention

U. S. Pat. No. 2,242,837 J. E. Shields, assignor to Alox Corp., May 20, 1941. A film forming protective composition adapted for use as an anti-corrosion material, consisting essentially of a mixture of neutral unsaponifiable oxidized mineral hydrocarbons including saturated aliphatic alcohols, saturated aliphatic ketones, saturated aliphatic keto-alcohols, and neutral esters and lactones of high molecular weight saturated aliphatic carboxylic acids, said oxidized mineral hydrocarbons being produced by controlled, liquid-phase, partial oxidation of a mixture of saturated mineral hydrocarbons, said mixture containing dispersed therein a lead salt of a relatively high molecular weight saturated aliphatic carboxylic acid of mineral origin, said acid having an end methyl group. Also may contain as a dispersion, a synthetic resin compatible with the other ingredients.

Organic Coating

U. S. Pat. No. 2,242,601 F. J. Wallace, assignor to Robeson Process Co., May 20, 1941. A lignin coating composition, useful as a varnish and lacquer comprising 5.0 parts of recovered lignin and 5 parts of cellulose nitrate dissolved in a solvent mixture comprising 45.0 parts of amyl acetate, 20.0 parts of methanol and 25.0 parts of turpentine, said recovered lignin being obtained from black liquor by precipitating the lignin in such liquor with an acid substance and recovering the precipitated lignin.

Degreaser

U. S. Pat. No. 2,243,093 R. F. Flakive, assignor to Leo Balles, May 27, 1941. An improved apparatus for solvent degreasing and cleaning.

Aluminum Coating Iron & Steel

U. S. Pat. No. 2,243,979 R. S. Reynolds, assignor to Reynolds Metals Co., June 3, 1941. A process including deposition of iron on a cathode under conditions favoring hydrogen absorption, stripping the iron deposit, densifying the surface to minimize dispersion of aluminum into the surface, and then, while the iron still retains the absorbed hydrogen immersing into a bath of molten aluminum.

S-310

CLEAR RUST INHIBITIVE

S-310 is a clear, pale liquid which can be reduced 150-200%. This solution can be applied to bright metal surfaces by dip or spray and gives a remarkably hard, tough and adhesive film of pronounced resistance to rust or tarnish.

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S-310 is indicated wherever a thin, hard, non-greasy film that resists rust in transit and storage is desired.

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Cleveland, Ohio

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Increase factory output ... Lower finishing costs. Let this modern, inexpensive machine solve your drying or lacquering problem.

Fully equipped with reversing drum switch, foot brake, ¾ H.P. motor, V belt drive, it is of all steel electric weld construction occupying 18" x 32" floor space. Gas or steam heating unit optional.

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Here's one of four 40,000 CFM Units recently installed to take care of dust from polishing, buffing and grinding of parts in a Detroit Airplane Motor Plant.

. . . designed to meet the exacting requirements of grinding, polishing, and sanding processes in IRON, ALUMINUM and MAGNESIUM ALLOY

You are now provided with a practical, sure, economical way of eliminating the dust hazard through the Hydro-Whirl—a wet dust collector. All dust is "water-whirled" out of the air and is formed into a sludge which is automatically removed by conveyor.

Great savings in building heating costs are obtained because the cleaned air may be returned to the building. No sparks can get through the ISM Hydro-Whirl. Standard parts are used throughout the units.

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617 E. FOREST AVENUE **DETROIT, MICH.**

Plant Re-arrangement Speeds Finishing Operations

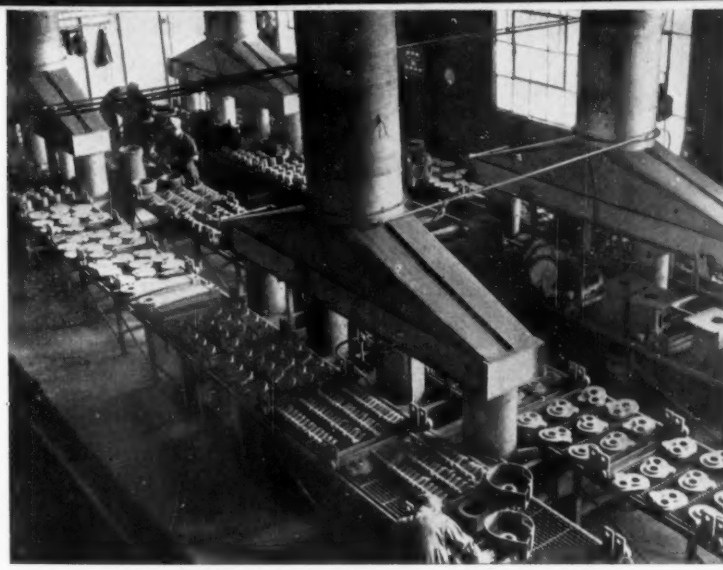


Fig. 1. Group of down-draft spray tables used for preliminary painting of small castings.

The increased demand for machine tools—largely traceable to the defense program—has made necessary the expansion of plant facilities at the Gisholt Machine Company at Madison, Wisconsin, manufacturers of turret lathes, automatic lathes, and balancing machines for detecting vibration in rotating parts and assemblies. Among the changes made was the enlargement of the painting and finishing departments and the re-arrangement of equipment in these departments for greater convenience, as well as other changes for improving working conditions.

The painting facilities at the Gisholt plant are operated independently in two separate and distinct sections. One section, consisting of a large down-draft spray booth and four conveyor lines, is located in the foundry building and handles the preliminary finishing of all castings. The other section is a large spray booth in the assembly plant, and is devoted solely to the finish painting of completed machines and turret lathe tools.

Four hand push conveyor lines with eight down-draft tables each, running parallel, and a fifth at right angles to the former, take care of the preliminary work done in the foundry paint shop, consisting of priming, filling, sanding, and sealing of gray iron and nickel steel castings, after they have been cleaned and snagged, prior to machining. One exhaust stack serves four tables.

The sealing coat is applied as a protection against the absorption of oil, dust, and chips, during subsequent machining operations. At this time, all cored castings are given an inside spray coat of yellow oil-resisting paint which materially increases the light reflecting qualities of the interior surfaces of the casting, making for greater visibility on machining and assembly operations. In passing the work over the down-draft tables, the castings are laid out on square grate trays fitted with rollers or wheels at each corner. There is also a hook at each corner of the table by which the tray, or buggy, may be handled to or from the table conveyor line by means of chains suspended from an overhead crane.

Large and cumbersome bed castings are filled and primed in a separate, down-draft floor booth close to the conveyor lines. At this point, the work is placed on four-wheel trucks mounted on tracks running into the spray booth. The paint lines serving this booth carry primer, filler, and sealer supplied from a nearby paint vault. After these preliminary painting operations, the castings are placed in tiered storage racks until the order is completed, when the parts are transported to the various machining departments.

Final Finishing

Over in the assembly plant and adjacent to the shipping department, is a large spray booth, divided into two sections, devoted entirely to final finishing. Upon completion of the testing procedure, turret lathes, automatic lathes, and balancing machines are transported to this finishing department by over head crane and lowered onto trucks mounted on tracks running into the spray booth, which accommodates six machines at a time. The sequence of painting operations on the completed machines consists of:

1. Wash with mineral spirits.
2. Wash with lacquer thinner.
3. Tape and grease all polished parts.
4. Apply coat of sealer (this brightens the finish and simplifies the detection of surface damages incurred in handling or machining).
5. Patch bad spots.
6. Entire machine hand sanded.
7. Apply two coats of sealer.
8. Apply one coat of lacquer.
9. Wet sand.
10. Apply two coats of lacquer.
11. Remove tape.
12. Spray slushing oil on all polished parts.

As a final finish, an air-drying pyroxlin base lacquer in machine tool gray is used, since it dries quickly and is oil resisting.

Not only has production capacity been increased by the re-arrangement of the finishing departments and the installation of new equipment, but in addition, greater efficiency in the movement of work to the foundry finishing department was gained by the re-arrangement of the storage facilities for small castings by the installation of structural steel shelves for the orderly storage of these parts, which formerly had been allowed to accumulate in production groups of 25 to 50 pieces on the foundry floor, while now production lots have been increased,—ranging in numbers from 50 to 100 pieces.

Furthermore, the installation of a "Hydro-blast" cleaning system has been instrumental in practically doubling the output of cleaned castings, and has reduced the amount of dust ordinarily created by hand methods to such a negligible quantity that it was possible to set up the preliminary painting lines in an adjacent area, reducing to a minimum the transportation of material from the cleaning and snagging section.

Electrolytic Descaling

Formerly, heat treated parts having heavy scale were transported to the foundry for sand blasting, after which

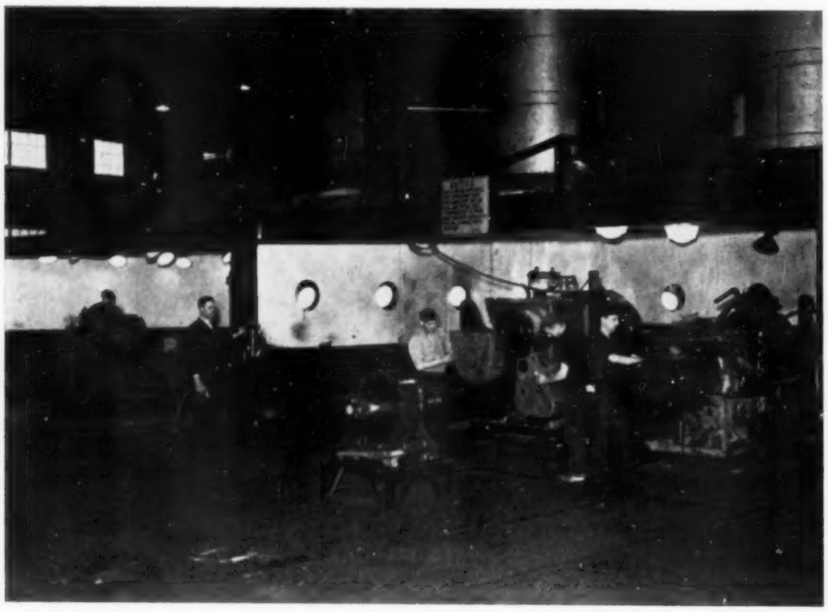


Fig. 2. Partial view of finish spray booth in assembly plant. Here completed machine tools are given final painting.

they were sent to the machine shop which is alongside the heat treating department. The installation of electrolytic cleaning equipment at one end of the heat treating section has eliminated the back and forth transportation of work, improved working conditions, lessened cleaning time, and sped up production. This equipment is used entirely for the removal of oxide scale from work composed mostly of headstock gears, gibs, and miscellaneous small hardened parts.

The electrolytic equipment is a rotary type machine, consisting of a group of five tanks into which the work is dipped and elevated while traveling along suspended from an overhead hydraulic conveyor. The complete cycle period being twenty minutes. The first tank contains an alkaline solution, the work being the anode; the second is a cold water rinse; the third tank is a hot sulfuric acid bath, where the work is the cathode; the acid bath is removed by a cold water rinse in the fourth, and a hot water rinse in the last tank.

A flash coating of tin is given to the work pieces as rapidly as they are descaled, all of which takes place in the acid tank. This prevents further acid attack on the piece being descaled.

Removal of Organic Coatings

U. S. Pat. No. 2,242,106 J. F. [illegible]ckman, The Enthone Co., May 13, 1941. A method of removing baked organic coatings which consists of immersion in an emulsion of water and a compound comprising in volumetric proportions, 10% - 80% of a material selected from the group consisting of cresylic acid, phenol, orthocresol, metacresol and paracresol, 5% - 10% of potassium oleate, and 5% - 10% of water, the amount of water added to the composition being in the proportion of 1 - 40 parts of water to 2 parts of composition, the immersion being continued until the coating is loosened after which the work is removed and rinsed in water.

Rust Prevention and Removal

U. S. Pat. 2,235,944 W. B. D. Penniman, March 25, 1941. A rust preventing and removing composition comprising about 10% of boiled linseed oil including drier, 2% of pine oil, 2% of oleic acid and the remainder petroleum oil distillate.

Shop Problems

Coating Rods

Question. We have a number of wooden rods which we wish to finish with a thin uniform coating of clear lacquer. The rods measure approximately thirty inches long by one-half inch in diameter. We are equipped to spray finish but we have found that spraying these rods is uneconomical of material and, more important, it is difficult to secure a uniform film. We have investigated dipping but it appears that even a crude dipping set-up would cost more than is feasible at the moment. Is there any other way we might finish these rods? Your aid in this matter will be most welcome.

Answer. It is possible that you could apply the thin uniform coat which you wish on the rods by the squeegee or wipe-off method. A simple vertical pipe closed at the bottom end and of sufficient length to take the rods plus a rubber wiper would be all that is necessary. Place the pipe vertically and fill it with lacquer. Place a thin sheet of rubber (automobile inner tube has been found practical), through which a hole has been punched, over the open end of the pipe. The rods may then be pushed through the hole in the rubber into the lacquer and, on withdrawing them through the hole, the rubber will wipe off the excess lacquer. You may have to experiment to find the correct diameter hole for the rubber. Cork borers, of the laboratory type used for making holes in stoppers, can be used to advantage for making holes.

Determining Hardness of Organic Finishes

Question. Will you be so kind as to send me details of the method for determining the hardness of organic finishes using pencils of various hardness. We wish to make quick periodic checks on our finishes for control purposes. From the small amount of information which I have received, it would seem that this method is best suited to our needs.

Answer. The test for hardness about which you inquire is made by drawing sharpened pencils of increasing hardness across the film and observing the scratching effect on the finish. The pencil hardness range which is used, beginning with the softest pencil is: 6B, 5B, 4B, 3B, 2B, B, HB, F, H, 2H, 3H, 4H, 5H, 6H, 7H, 8H and 9H.

In general, finishes which can be scratched with pencils of from 6B to HB hardness are too soft to resist any great amount of mechanical abuse. Finishes which may be scratched by pencils of from HB to 2H hardness are sufficiently hard to withstand mild handling, etc. Those finishes which require 2H to 7H hard pencils to scratch them are usually quite hard and mar-resistant. Finally, finishes which require pencils of 7H hardness or above are hard and practically mar proof.

It must be pointed out that many variables exist in this method, such as the sharpness of the pencils, the pressure applied, the angle at which the pencil is held, etc. However, an operator can, with some practice, grow quite proficient in using this method.

New Products

Substitute for Aluminum Paint

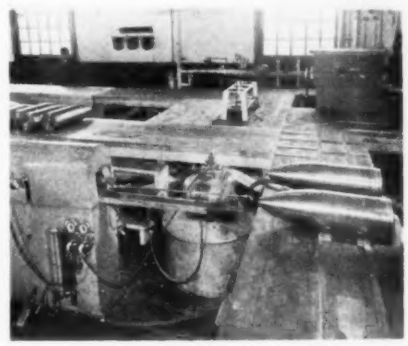
The Wilbur & Williams Co., Park Sq. Bldg., Boston, Mass., have announced the development of a product which can be used as a substitute for aluminum paint.

The paint called "Light Gray Totrust" is said to look like aluminum and to have approximately the same light reflectivity as aluminum paint. It is also reported to possess all of the features of aluminum paint, and to cost much less.

The paint is claimed to contain a unique oil vehicle which penetrates pin holes and pits, to give higher protective power and to form an isolating film around rust particles. It is stated that the paint can be applied directly over galvanized metals; that one gallon covers approximately 800 to 1200 sq. ft.

Unit for Varnishing Shells

Paasche Airbrush Co., 1909 Diversey Parkway, Chicago, Ill., have built a new automatic air coating unit for use in varnishing the interior of 9.2" shells as illustrated.



Unit for varnishing interior of shells.

The shells are rolled along the runway at the right, stopping on the two rotating wheels immediately in front of the airbrush extension. As this happens, the airbrush extension is released and same extends into interior of shell. As the shell begins to revolve, the extension is automatically withdrawing slowly therefrom and the shell interior is then covered entirely and evenly with varnish and with no waste of material.

Viscosimeter

A recent bulletin issued by *General Electric Co.*, Schenectady, N. Y., describes and illustrates the "G-E Zahn Viscosimeter" for quick and accurate measurement of the viscosity of oils, paints and similar bodied materials. The operation consists of filling the cup of the viscosimeter and measuring the time required for the cup to empty. The readings are stated to be sharp, rapid and accurate and the equipment is portable and economical.

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PREPARATION, ELECTROPLATING, COATING

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CONTENTS

DEPARTMENTS

METAL FINISHING (formerly Metal Industry) has been the leading publication since 1903 in the field of metal preparation, electroplating and coating.

VOL. 39, NO. 8 METAL FINISHING AUGUST, 1941
PREPARATION, ELECTROPLATING, COATING

The Metal Situation

The unprecedented shortage of material is already having profound effects on the non-defense portion of industry. Curtailments in production and lay-off's of employees are occurring at an increasing rate and this rate will greatly accelerate when the dwindling material reserves of manufacturers are gone, and the defense orders are expanded. The plating industry in the non-defense portion of industry is suffering severely. The reduction in the automobile industry will be a particularly severe blow to the plating industry.

The following metals or materials used extensively in plating have been placed under mandatory control of the Priorities Division of OPM: nickel, copper, borax (and boric acid), zinc, chromium, rubber and polyvinyl chloride (used in tank linings and rack coatings).

The Priorities Division of OPM exercises inventory control over: Antimony, cadmium, cobalt, iridium, lead, mercury, tin and various non-ferrous alloys and scrap metals. This form of control requires suppliers of these metals as well as customers for these metals, to file monthly statements of compliance.

A Priorities Critical List containing over 300 items and classes of items has been compiled on which army and navy orders can be automatically given priority. Although some of these 300 items are under industry-wide control, most of them are subject to control only in the sense that army and navy orders can automatically be granted priority. Some of the materials used in the finishing industry and on this list are: Acetone, ammonia, boric acid, chlorine, sisal, cresols, cresylic acid, formaldehyde, methanol (wood alcohol), phenol, phthalic anhydride, potassium permanganate, sodium hydrosulfite, tricresyl phosphate.

An estimate made a short time ago of the ratio of demand to supply of metals after defense requirements have been filled, was as follows: Aluminum 15 to 1, copper 5 to 2, nickel 2 to 1, zinc 3 to 2, tin 3 to 2, mercury 3 to 2, plastics 3 to 2, nitrates 8 to 7, rubber 10 to 7, lead 1 to 1. Of course, a severe dislocation in shipping facilities could easily vastly change these ratios. It may thus be seen that there will be insufficient supply to meet civilian demands for all of the substances mentioned.

Figures on copper supply indicate that the total amount of refined copper available in this country from all sources during 1941 may range as high as 1,600,000 short tons. But total military requirements, plus civilian demand, are expected to range close to 1,950,000 short tons, thus indicating an overall shortage for the year of approximately 350,000 short tons.

All these figures are estimates. The shortage would be increased by any shipping difficulties which prevented this country from obtaining additional supplies of refined copper from Chile.

The developments in the Far East have occasioned sharp increases in the price of tin which may force OPACS to impose a price-ceiling on tin in the near future. Should a price-ceiling prove necessary, it was emphasized that no special consideration will be shown to persons who henceforth acquire tin at recent high prices. The Government buying price is 50c a pound and the current price for tin is 55c a pound. Leon Henderson, price administrator of OPACS, hopes that the prices will stabilize around the 50-cent level.

General Preference Order No. M-18, has placed chromium under mandatory priority. This order refers to ores or concentrates containing chromium, the element chromium, refractory bricks and refractory material of chromium, and most important to the plating industry, of chemical combinations having chromium as an essential and recognizable component which, therefore, includes chromic acid. A rating of A-10 has been assigned to all defense orders and after defense orders have been filled, deliveries for non-defense orders may be made.

Lead is not under mandatory priority control at the present time and orders should be placed with regular suppliers before applying to the OPM for allocations of lead held by the Metals Reserve Company of the Reconstruction Finance Corporation.

Notes on Rectifiers

Output Voltage and Current

By L. W. REINKEN

Chief Engineer, W. Green Electric Co., Inc., New York

In an earlier article, "Rectifiers Allow Power Flexibility", issue of February 1941, the author outlined some of the advantages of rectifier power supplies for electrofinishing. Correspondence and comments since then indicated that further discussion on certain electrical characteristics of rectifiers would be of interest to our readers. The following notes apply, in general, to most types of rectifiers.—Ed.

THIS article will be limited to notes on the relationship between the output voltage of rectifier equipments and factors such as control apparatus in the rectifier, tank rheostats, tank load, etc. For a more general discussion of rectifiers see "Metal Finishing," February 1941.

Substituting Rectifiers for Generators

Before discussing more complicated factors may we take time out to squelch a superstition which has arisen about rectifiers. There is no reason, technical or commercial, why a single rectifier unit may not be used to supply power to *any* number of tanks. It is perfectly practicable to replace a motor generator in *any* plating plant layout by a single rectifier installation of equivalent voltage and current capacity, without making any other change in the layout.

Planning for Rectifiers

There are very definite advantages to be obtained by planning the layout so as to divide the tanks into groups of equal voltage, and supply each group from a separate rectifier unit.

This arrangement provides flexibility in operation and flexibility for future rearrangements in the plant. In addition, there is a considerable saving in power by eliminating tank rheostats, since all voltage control is centered in the rectifier units which permit voltage control without large power dissipation. As will be shown later, the elimination of tank rheostats provides other advantages in operation.

However, many existing plants cannot adopt this scheme as readily as can new plants now under construction, or, operating conditions may not justify a complete changeover. May we repeat, for the benefit of those who operate such plants, that a rectifier of correct capacity *may be used to supply any number of tanks.*

Voltage Control

Most rectifiers incorporate apparatus providing complete control of the output voltage. This control gear, which may be included in the same cabinet as the main rectifier unit, or may be housed in a separate control box, is usually equipped with two control knobs or levers. The first of these varies the output in relatively coarse steps—for example about $\frac{3}{4}$ volt or 1 volt per step on a 6 volt equipment. This control is used to approximate the desired voltage. Then the second or "fine" control which might be likened to a "vernier" control, is used to adjust the output to the exact value desired. The second control provides much smaller steps—for example about 0.1 to 0.2 volt per step on a 6 volt rectifier.

The total voltage variation which can be produced by rotating the "fine" control from minimum to maximum usually is equal to one step on the coarse control. Thus, by adjusting the two controls it is possible to cover the whole range in quite small steps. The total number of steps is therefore equal to the product of the steps on the two controls. (To be strictly accurate we should not count those few combinations which duplicate voltages in order to insure a continuous control without gaps.)

Typical numbers of steps used on rectifier voltage controls are 6 and 6, 7 and 7, 8 and 8. These provide 36, 49 and 64 steps of control respectively.

Range of Voltage Control

Most rectifier voltage controls cover a wide range in output voltage. Typical 6 volt rectifiers can be accurately adjusted (to within about 0.1 volt) to deliver any desired output voltage between 1 and 6 volts at any load.

On rectifiers of higher output voltage, the ratio of maximum to minimum voltage is usually about the same, that is, about six to one. For example, on 12 volt rectifiers the range would be 2 to 12 volts, and the accuracy of setting would be about 0.2 volt.

Advantages of Rectifier Voltage Control

The chief advantage of the type of voltage control system described is that it provides a wide range of control without wasting power in the form of heat.

Another advantage of this type of voltage control is the ease with which it may be modified to meet any desired requirements. For example, the minimum voltage may be extended right down to zero. Or, if extremely low voltages will not be required, the minimum voltage may be increased to 3 or 4 volts, thus providing increased fineness of control over the more restricted voltage range.

Some custom-built rectifiers offer a choice of additional steps to obtain still finer control of output voltage.

Voltage Variation with Load

Unless special (and expensive) compensating devices are incorporated, it is characteristic of all electric power supply devices, that the output voltage from the supply unit will decrease as the load is increased. Or, this may be stated another way by saying that as the load is decreased, the output voltage will tend to rise.

For example, assume that a 1000 ampere rectifier unit has been adjusted to have an output voltage of 6 volts when delivering 1000 amperes. If the load is reduced to 500 amperes the voltage would rise to possibly 6.5 volts. Similarly, if the rectifier controls were adjusted to deliver *3* volts at 1000 amperes, then reducing the load to 500 amperes would cause the voltage to rise to approximately *3.5* volts.

This phenomenon, which is known as "voltage regulation" is a natural consequence of the internal resistance of the rectifier or other power supply source. The phenomenon can be more strikingly demonstrated by artificially increasing the resistance in the circuit. This is discussed in the following section.

Tank Rheostats and Voltage Regulation

A tank rheostat is a very simple application of one form of Ohm's Law. This form is written algebraically as follows:

$$E = IR, \text{ where } E = \text{voltage}$$
$$I = \text{current}$$
$$R = \text{resistance}$$

In practical politics, this is a shorthand way of saying that the voltage difference "E", between the bus-bar voltage and the tank voltage, is arithmetically equivalent to the product of the tank current "I", and the resistance "R" of the tank rheostat.

For example, assume that the bus-bar voltage is 6 volts, the current into the tank is 1000 amperes, and the resistance of the tank rheostat is 0.003 ohm. Then, the voltage drop is:

$$E = IR = 1000 \times 0.003 = 3 \text{ volts.}$$

The tank voltage will then be equal to the bus-bar voltage minus the rheostat drop, or:

$$\text{Tank voltage} = 6 - 3 = 3 \text{ volts.}$$

(May we point out here that the power dissipated in the form of heat in the tank rheostat is $P = EI = 3 \times 1000 = 3000$ watts. This power does not do any useful work in the plating tank but does appear on the electricity bill.)

Now, let us see what happens when we reduce the tank current, as we did before, to 500 amperes. The voltage drop across the tank rheostat at this current will then be:

$$E = IR = 500 \times 0.003 = 1.5 \text{ volts.}$$

The tank voltage at 500 amperes will then be:

$$6 - 1.5 = 4.5 \text{ volts.}$$

In other words, the tank voltage will rise from 3 volts to 4.5 volts, when the tank current is reduced from 1000 to 500 amperes, *even if we assume that the bus-bar voltage remained absolutely constant.*

Of course, if the power supply voltage regulation caused the bus-bar voltage also to rise, from 6 to 6.5 volts, then the total tank voltage rise would be from 3 to 5 volts. This is a rise of 2 volts, four times as great as the 0.5 volt rise characteristic of the rectifier system in which no tank rheostat was used.

Typical rectifier control and meter panels. Left control is for coarse adjustment of voltage and right control is for fine adjustment.

Constant Potential Generators

It has already been stated that all power supply devices are characterized by voltage variation with load, unless special compensating devices are provided.

In some generators, a special arrangement automatically increases the internally generated voltage to compensate for the rising internal voltage drop with increasing load. In effect, a generator of this type will provide a substantially constant output voltage over a comparatively wide range of output current. A typical specification for such a generator would be—"Output voltage constant to within plus or minus 3% of the rated voltage, from no load to full load." The variation in output voltage would be somewhat greater when the generator is set to deliver less than its rated voltage.

Such a generator would provide practically constant voltage across the bus-bars, also across any tank connected *directly* to the bus-bars without a tank rheostat. Unfortunately, as already shown, the voltage will not be constant across tanks using rheostats between the tank terminals and the bus-bars.

Constant Potential Rectifiers

The question is sometimes asked—

"Is it possible to construct a rectifier which, like the

constant potential generator, would have a substantially constant output regardless of current output?"

The answer to this question is an unqualified "Yes." As a matter of fact, constant potential rectifiers of extremely constant voltage and fairly high outputs have been built for other applications such as power supply units for large telephone exchanges.

There are several reasons why constant potential rectifiers have not yet been offered for electrofinishing use. For those who may be interested, here are some of the reasons.

(1) A certain amount of positive voltage regulation is necessary to insure stable operation when two or more rectifiers are connected in parallel or series to be operated as a single power supply source. (See Feb. 1941 issue.)

(2) As already explained, the advantages of "constant potential" are nullified if tank rheostats are used. Constant potential units are therefore advantageous only when they are used to supply a single tank, or a group of tanks all operating at the same voltage.

(3) The voltage compensating equipment is comparatively bulky and expensive.

(4) Where it is desired to keep the voltage at one tank independent of operations in a second tank, it is more economical to provide two smaller separate rectifiers, than to use one large rectifier equipped with constant potential voltage compensation.

Furthermore, the two separate rectifiers are much more flexible, require less bus-bar, and permit the tanks to be operated independently at different voltages without the use of tank rheostats.

Ripple Voltage

In electroplating, we speak of the output from our generators or rectifiers as "direct current." With sensitive devices such as a cathode ray oscillograph it is possible to get an actual picture which shows that the output is really "*pulsating* direct current." The oscillograms show that the output voltage appears, not in the form of an absolutely straight line, but rather as a wavy or jagged line.

For example, a motor generator delivers "direct" current (current in one direction) which varies rapidly above and below an average value. These up and down variations are proportional in frequency to the number of segments on the commutator and the speed at which the generator rotates. "Ripple frequency" as it is called, is different for different types of generators. This ripple in the output voltage is of such high frequency that it cannot be indicated by corresponding fluctuations in the output meters. The meters indicate the average value, above and below which the variations occur. If the meters *do* show any periodic flutter ("rhumba rhythm") in the output, it is indicative of variation in speed, difference between commutator segments, poor brush contacts, or other accidental cause of non-uniformity.

Rectifiers do not have commutators or moving parts, but they also have ripple voltage in the output. The function of a rectifier, in simple language, is to turn the negative halves of the A.C. supply "upside down" so that both halves of each complete cycle flow in the same direction (D.C.) through the load or tank. The frequency of the ripple voltage depends only upon the frequency of the A.C. power supply, the type of power supply (single or three phase), and the circuit used (half wave or full wave). The following table shows the ripple voltage frequencies in the outputs of different rectifiers operating from 60 cycle power supplies—

Phase	*Circuit*	*Ripple Frequency*
Single	Half wave	60 cycles per second
"	Full "	120 " " "
Three	Half "	180 " " "
"	Full "	360 " " "

The first of these circuits—single phase half-wave—is rarely used in electroplating rectifiers, not because of its ripple frequency but because single phase full wave is equally economical and more efficient.

Neither in generators nor in rectifiers has there been found any evidence to show that the ripple frequency or the percentage of ripple has an adverse effect on any type of electrofinishing. A few people are attempting to determine a correlation betwen ripple voltage and electroplating, electropolishing or anodizing. No positive results have been published, although there are rumors that in some types of electroplating high ripple voltage actually produces a finer-grained deposit of better adherence.

Summary

(1) The number of tanks operated from a single rectifier is limited only by the capacity of the rectifier. In any existing layout, a motor generator may be replaced by a rectifier of the same capacity.

(2) If convenient, it is desirable to plan the layout so that tanks requiring the same voltage are grouped together, and each group is operated from a separate rectifier. In the ideal layout each tank would have its own rectifier. This provides maximum operating economy, complete independence of control, flexibility for future layouts, minimum bus-bar connections, and elimination of tank rheostats and tank meters.

(3) Most rectifiers are equipped with voltage controls providing a convenient and accurate control over an unusually wide range of output voltage. In custom-built equipments, the voltage control system can easily be designed to meet any special requirements.

(4) Whatever the source of power supply, the use of tank rheostats greatly exaggerates variations in tank voltage with changes in tank current. Tank rheostats also consume considerable power. Rectifiers equipped with voltage controls provide a practical means of dispensing with tank rheostats thus reducing tank voltage variations and economizing on power consumption.

(5) All sources of power supply (excepting batteries) used for electrofinishing are characterized by a ripple in the output. The frequency and percentage of this ripple varies widely depending upon a number of factors. There is no evidence that ripple voltage is harmful—and it may be desirable.

A Study of Citrate Additions to Copper Cyanide Plating Solutions

By CHESTER W. SMITH and CHARLES B. MUNTON

Introduction

SINCE imports of tartrate have recently been curtailed and rochelle salts are very difficult to obtain, interest in substitute materials has been intensified. The possibility of other organic acid salts having similar effect upon the operation of cyanide copper solutions has long been a point of speculation.

The effect on the cathode deposit, and cathode and anode efficiencies under conditions similar to those in use in rochelle salt type copper solutions is one of the points of particular interest in the consideration of any addition material. The optimum concentration of the citrate ion, as well as other ions and standards of operation must be determined in order to draw a direct comparison with the optimum conditions which are accepted for the rochelle salt-cyanide copper solution.

In certain instances this preliminary investigation checks with work done by Dr. A. Kenneth Graham. It was found that a carbonate content of 4 to 5 ounces per gallon increased the cathode efficiency.

Commercial installations of potassium-sodium citrate-cyanide copper solutions have been in operation for several months, and the results in operation coincide with the results of this investigation, namely, the deposits from the citrate solution are equal in all respects to those out of the rochelle type bath. The appearance of the deposit is somewhat more lustrous, but this is more noticeable only in heavier deposits. No roughness or objectionable anode polarization has been encountered. The consumption of sodium citrate also appears to be less than rochelle salts.

PART I

Efficiency Comparison of Potassium-Sodium Citrate-Copper Cyanide Bath to a Rochelle Salt-Copper Cyanide Bath

Experimental Procedure

The following report has as its object the comparison of efficiencies of the citrate copper bath and the rochelle salt copper bath under similar operating conditions. Where the constituents or operating conditions of one bath were varied, the other was varied accordingly, in order to eliminate as much as possible all differences between the two baths and obtain accurate figures on their operating efficiencies.

Three baths were connected in series with one another: the citrate solution, the rochelle salt solution and an acid copper solution. The acid copper solution operated at 99% plus efficiency and served as a coulometer. By using a series hook-up the working current was distributed equally among the three baths.

The anodes and cathodes of the citrate and rochelle salt baths were carefully cleaned and weighed preparatory to

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Engaged in the field of electroplating for the past 8 years. Affiliated with the J. C. Miller Company of Grand Rapids, Michigan as chief chemist working on research and development of materials for the field of electroplating. Member of the American Chemical Society and the American Electroplaters' Society. Active in the A.E.S. as Vice President and Librarian of the Grand Rapids Branch during the last few years. National Convention Chairman for the 1942 American Electroplaters' Society Convention in Grand Rapids.

Hobby: Sailing on the inland lakes of Michigan and playing with the baby when at home.

CHARLES B. MUNTON was born September 6, 1916. Received elementary and High School education in Grand Rapids, Michigan. Chemical training at Grand Rapids Junior College and Michigan State College, graduating from the latter with a B. S. degree in 1940. While at Michigan State College majored in Physical Chemistry under Dr. Ewing. Located with the J. C. Miller Company in the summer of 1940. At present time is assistant chemist engaged in development work and research in the chemical laboratories of the J. C. Miller Company, Grand Rapids, Michigan.

Charles B. Munton

plating and then placed in the respective copper solutions, and a current of 50 amperes per sq. ft. passed for a period of 20 minutes. The anodes and cathodes were then removed, rinsed in water, dipped in alcohol, dried in the constant temperature oven for 15 minutes, allowed to cool to room temperature and weighed on an analytical balance. The anodes used in these two baths were of pure electrolytic copper, the cathodes of cold rolled strip steel.

The cathode of the acid copper bath, or coulometer bath, was of pure electrolytic copper and cut to such a size that when the citrate bath and rochelle salt bath were receiving a cathode current equivalent to 50 amperes per sq. ft., the coulometer cathode current density amounted to 8 amperes per sq. ft. The cathode of the coulometer was weighed before and after electrolysis and the amount of copper deposited taken as a gauge of the current which had passed through the baths during electrolysis.

The cathodes of the citrate bath and the rochelle salt bath were the only pieces to be cleaned in the electrolytic cleaner. These pieces were of cold rolled strip steel, covered with an oil film to prevent rusting. The pieces were cleaned in the electrocleaner using reverse current for from 15 to 30 seconds. The pieces were rinsed, dipped in 3% sulphuric acid, rinsed, dipped in 95% ethyl alcohol and placed in a constant temperature oven to dry for 15 minutes at a temperature of 210° F. The steel strips were removed from the oven, allowed to cool to room temperature, and weighed on the analytical balance. The strips were then ready to serve as cathodes in the copper baths.

The anodes were thoroughly cleaned before first being used and for the remainder of the runs were rinsed in water, dipped in alcohol, dried, weighed and were then ready for the next run without further cleaning.

The same procedure used for the anodes was used for the coulometer cathode.

The citrate bath and the rochelle salt bath were identical in composition except in two respects. The first and obvious difference was that the rochelle salt bath contained rochelle salts, and the citrate bath contained sodium citrate. The second distinction lay in the caustic content of the two solutions. Sodium hydroxide was used to adjust the pH of the rochelle salt bath; potassium hydroxide was used for the same purpose in the citrate bath. The use of potassium hydroxide to raise the pH in the citrate bath served two purposes: it raised the pH of the bath by virtue of its hydroxyl ion content, and it supplied the potassium anion.

Below is given the composition of the two baths.

TABLE I

Rochelle Salt Bath		*Citrate Bath*
Copper metal	1.95 oz./gal.	Copper metal
Free cyanide	0.75 " "	Free cyanide
Carbonate	2 " "	Carbonate
Rochelle salts	4 " "	Sodium citrate
pH (NaOH)	12.6	pH (KOH)

Test runs were made on the two solutions in 300 ml. samples. These samples were contained in 300 ml. beakers and placed on individual hot plates with temperature control. Each bath contained one anode and one cathode of equal area.

After 300 ml. of each solution had been measured into a beaker, the beakers were placed on a hot plate and brought to a temperature of 150° F. The anodes and cathodes were then placed one each in the beakers, a temperature check made, and the two copper baths connected with the coulometer. A current of 50 amperes per sq. ft. was then applied for 20 minutes with temperature checks made regularly throughout the run, and the temperature adjusted to 150 degrees if necessary. At the end of the run the anodes and cathodes were cleaned and weighed and another run prepared in the same manner as the above.

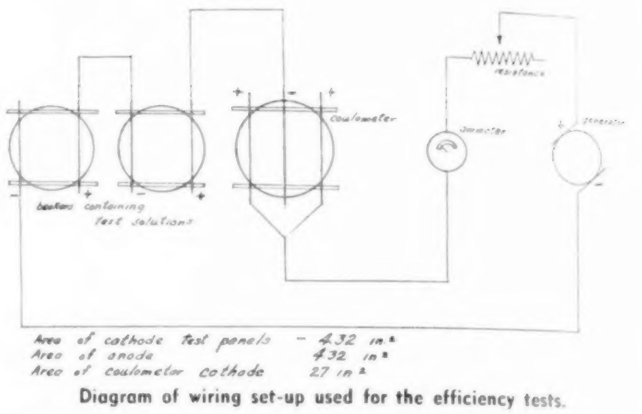


Diagram of wiring set-up used for the efficiency tests.

Three series of plates were run on each type bath, with 5 runs to each series. The first series consisted of citrate and rochelle salt concentrations of 4 ounces per gallon in their respective baths. The carbonate content was varied from 2-14 oz./gal. in 3 oz./gal. additions. The second series was similar to the first series with the exception that the citrate and the rochelle salt concentration were raised to 6 oz./gal. The third and last series contained 8 oz./gal. of citrate and rochelle salts respectively in the two baths. In this manner, the efficiencies of the two solutions were compared with each other over a wide range of carbonate and rochelle salt and citrate concentration.

The chart below shows briefly the variation in composition of the two solutions throughout the experiment:

TABLE II

Run No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Rochelle Salt oz./gal.	4	4	4	4	4	6	6	6	6	6	8	8	8	8	8
Carbonate oz./gal.	2	5	8	11	14	2	5	8	11	14	2	5	8	11	14
Citrate oz./gal.	4	4	4	4	4	6	6	6	6	6	8	8	8	8	8
Carbonate oz./gal.	2	5	8	11	14	2	5	8	11	14	2	5	8	11	14

In addition to computing the efficiencies during the many runs, an analysis of copper metal and free cyanide in the solutions was made after each run had been made. In this manner, changes in copper metal content or cyanide content could be traced and conditions under which they occurred determined. It should be emphasized at this point that a new solution for both the citrate bath and rochelle salt bath was used for each run. No solution was used more than once. By following this procedure, a more strict uniformity was established and additional variables eliminated.

No special type of apparatus was needed for this work outside of that regularly used in laboratory plating. The

diagram on the following page shows the equipment which was used and its arrangement during operation.

The conclusions drawn from this work can be only general in scope, and the figures on any one run must be taken as indicative and not absolute. A constant temperature bath to control effectively the temperature of the two copper baths was lacking. The heating arrangement that was used consisted of individual hot plates, one for the rochelle salt copper bath and one for the citrate bath. This set up proved to be unsatisfactory in that temperatures could not be held constant at 150° F. during the 20 minutes of electrolysis. Thus, as often happened even though the temperature of the two baths checked at 150 degrees at the beginning of the run, a variance of as much as 4 to 6 degrees would creep in by the end of the run despite all measures taken to prevent such a change. As both baths are very sensitive to temperature changes, this condition has resulted in efficiency figures than can not be taken as absolute, but only indicative in character. Where the temperature change was very noticeable the run was repeated.

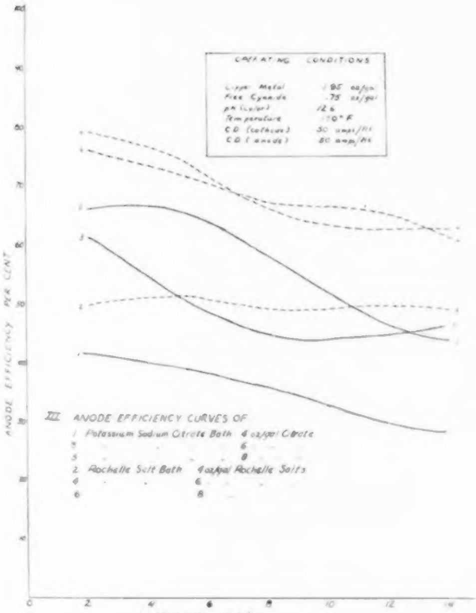
TABLE III

Table of Efficiency Values of The Rochelle Salts Copper Cyanide Bath and the Sodium Potassium Citrate Copper Cyanide Bath

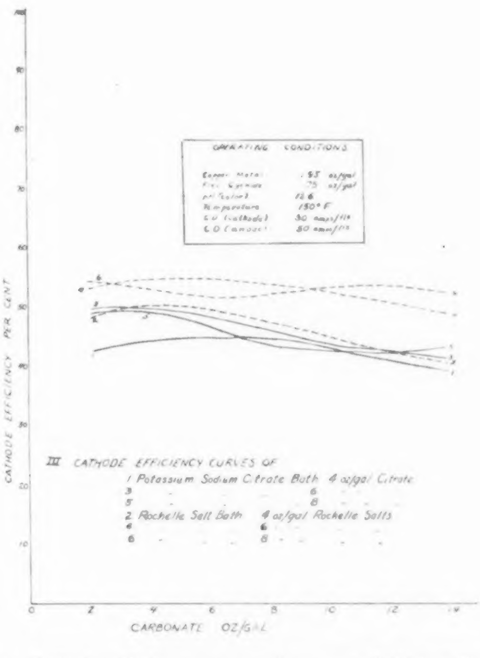
Run No.	Carbonate oz./gal.	Rochelle Salts oz./gal.	Cathode Effic.	Anode Effic.	Sod. Pot. Citrate oz./gal.	Cathode Effic.	Anode Effic.
1	2	4	48.2%	49.5%	4	41.0%	42.0%
2	5	4	51.0	54.7	4	44.5	39.5
3	8	4	46.6	47.8	4	46.0	36.3
4	11	4	44.0	49.8	4	40.0	31.0
5	14	4	40.8	48.6	4	39.6	28.0
Ave.			46.1%	50.0%		42.2%	35.3%
6	2	6	51.3%	79.3%	6	48.7%	66.4%
7	5	6	56.5	75.0	6	49.3	50.0
8	8	6	49.6	65.0	6	41.9	47.8
9	11	6	54.4	68.7	6	44.8	42.5
10	14	6	48.0	60.2	6	41.9	50.0
Ave.			51.9%	69.6%		45.3%	51.3%
11	2	8	54.0%	76.3%	8	49.0%	65.8%
12	5	8	51.9	72.2	8	48.2	67.7
13	8	8	52.2	66.5	8	39.9	57.1
14	11	8	53.9	58.0	8	44.3	45.8
15	14	8	52.3	64.7	8	44.3	44.4
Ave.			52.8%	67.5%		45.1%	56.1%
Average of 3 series			50.2%	62.4%		44.2%	47.5%

Results

Throughout the three series the rochelle salt bath operated at cathode efficiencies from 1 to 12% higher than the citrate bath. In no case did the efficiency of the citrate bath exceed that of the rochelle bath. For the series in which the rochelle salt and citrate were held at 4 oz./gal. respectively, the efficiency of the rochelle salt bath averaged 3.9% higher than that of the citrate bath. At a concentration of 6 oz./gal. of rochelle salts and citrate, the efficiency of the rochelle salt bath averaged 6.6% greater than that of the citrate bath. For the 8 oz./gal. series, the rochelle salt efficiency increased to an average of 7.7% over the citrate bath. An average taken over all three series, 15 test runs, shows



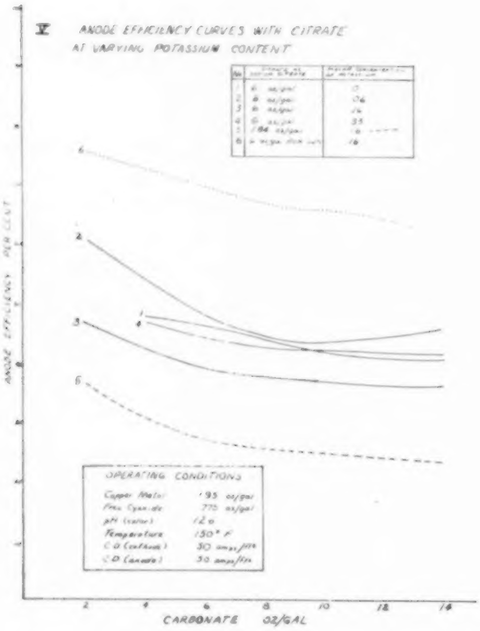
Graphs III. Anode efficiency curves of copper solutions with potassium sodium citrate and Rochelle salt additions.



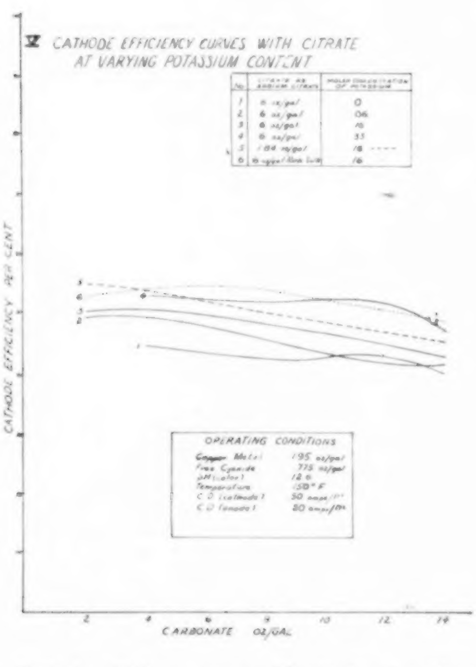
Graphs III. Cathode efficiency curves of copper solutions with potassium sodium citrate and Rochelle salt additions.

the rochelle salt bath to be 6.0% higher in efficiency than the citrate bath. The highest average rochelle salt efficiency was 50.2%, the citrate 44.2%. The greatest rochelle salt copper bath efficiency occurred at a concentration of 8 oz./gal. of rochelle salt with a calculated efficiency of 52.8%. The greatest citrate efficiency was 45.3% and was recorded as an average for the series in which the citrate content was 6 oz./gal.

All plates throughout the series were run at a current density of 50 amp. per sq. ft., and the deposits were uniform in appearance. Deposits from both baths were light pink in color and showed a decided luster. The deposits from the citrate bath *appeared superior* in many respects to



Graphs V. Anode efficiency curves with citrate at varying potassium content.



Graphs V. Cathode efficiency curves with citrate at varying potassium content.

those from the rochelle salt bath. Whereas the deposits from the rochelle salt bath were apt to show evidence of streaking around the perforations on the steel strips, the citrate deposits remained uniform in color and texture over the entire surface of the plate. Deposits from the citrate bath possessed a lighter, brighter sheen than those from the rochelle salt bath. The citrate deposits were smoother on high current density areas, (around the edges and on the corners) and showed no tendency toward burning or roughness, which is characteristic of rochelle salt baths on high current density areas.

As was the case with the cathode efficiency, the anode efficiency of the rochelle salt bath ran from 5-20% higher than that of the citrate bath averaging 14.9% greater efficiency throughout the entire series. At no time did the anode efficiency of the citrate bath exceed that of the rochelle salt bath.

The average anode efficiency of the rochelle salt bath was 62.4%; that of the citrate bath was 47.5%. The anode efficiency of the rochelle salt bath reached its highest point when the concentration of rochelle salts in the bath was 6 oz./gal.; that of the citrate bath occurred at a citrate concentration of 8 oz./gal. With the exception of the citrate bath where the concentration of the citrate was 4 oz./gal., the anode efficiencies of both baths were greater than their respective cathode efficiencies, thus assuring the free solution of anodes at the various concentrations of carbonate and rochelle salt and citrate. The margin of anode to cathode efficiency was greater in the case of the rochelle salt bath than of the citrate bath. The anode efficiency of the rochelle salt bath throughout the series was 12.2% higher than the cathode efficiency. The margin was greatest (17.7%), at a rochelle salt concentration of 6 oz./gal. and least (3.9%), at a rochelle salt concentration of 4 oz./gal. For the citrate bath, the average anode efficiency exceeded the average cathode efficiency by only 3.3%. The margin was greatest (11.0%), at a citrate concentration of 8 oz./gal. and was negative at a citrate concentration of 4 oz./gal. where cathode efficiency exceeded anode efficiency by 6.9%. Although this latter figure may not be exact, there is no doubt that the anode and cathode efficiencies are very close to one another at a citrate concentration of 4 oz./gal.

Both baths showed anode polarization, the citrate bath to a greater degree than the rochelle salt bath. Furthermore, in both baths, the anode polarization tended to increase as the concentration of carbonates increased over 5 oz./gal.

The anode of the rochelle salt bath discolored and formed a bluish green film, (cupric hydroxide), which tended to dissolve immediately upon cessation of the current. The anode in the citrate bath formed a dark brown, rather insoluble film on the anode, a film which dissolved very slowly after current ceased to flow. This film was undoubtedly a complex of cupric oxide and cupric citrate which interferred greatly with anode solution. Thus, the essential difference in anode behavior consisted in the differences of the films formed on the anodes during electrolysis, the one film soluble, the other slowly soluble.

As previously noted, the citrate bath does not compare in efficiency to the rochelle salt bath. But, in many other respects, the citrate bath appears superior to the rochelle salt copper bath. The plates from the citrate bath are smoother, more lustrous, lighter in color and show no streaking or burning under conditions where the rochelle salt bath invariably burns or streaks. The anode efficiency is a great deal lower than that of the rochelle salt bath, but this condition can be easily remedied by increasing the anode area either with soluble copper anodes or insoluble steel anodes, and thereby lowering the anode current density. The anode current density in this work ran between 50-60 amperes per sq. ft. for both baths, a figure which is quite high for even a rochelle salt copper bath. The polarization which exists in the citrate solution may result in the deposition of copper of a finer grain structure. The reason

for the increased polarization in the citrate bath may be due simply to the fact that sodium citrate has less of a depolarizing effect than rochelle salts. Sodium citrate corrodes the anodes less rapidly and forms a complex anode reaction product, copper oxide and copper citrate, which is slowly soluble.

A certain amount of carbonate appears beneficial to the copper bath. Cathode efficiencies, and in some cases anode efficiencies, are increased 3-6% with an addition of carbonate up to 5 oz./gal. Above this concentration the trend of cathode and anode efficiencies is downward with increasing additions of carbonate. The citrate bath appears especially sensitive to increase in carbonate content above 5 oz./gal. This is shown by the decrease in anode efficiency in each series from 11-16% with additions of carbonate from 5 to 14 oz./gal.

In the rochelle salt bath, the anode efficiency drops on an average of 9% when additions of carbonate above 5 oz./gal. are made. The cathode efficiencies in both baths are less affected, decreasing at most only 6-7% when additions of carbonate are made from 5-14 oz./gal. In one case, the rochelle salt bath with a rochelle salt concentration of 8 oz./gal. showed an average variation of only 2% in cathode efficiency throughout a variation of carbonate concentration from 2-14 oz./gal. The optimum carbonate concentration for both baths seems to be from 2-5 oz./gal.

Conclusions—Part I

The following conditions are those upon which the conclusions given below are based:

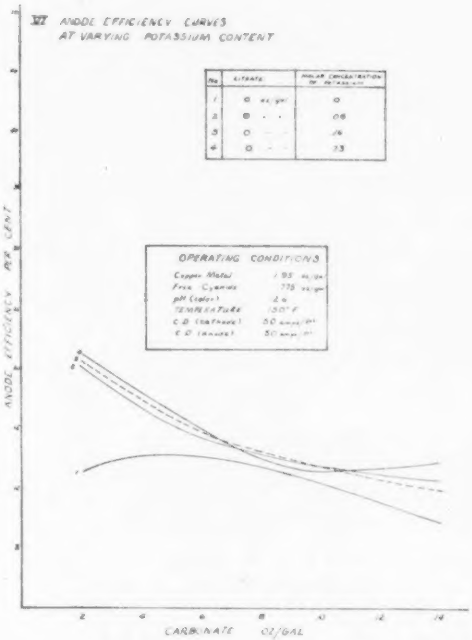
Copper metal	1.95 oz./gal.
Free cyanide	0.750 " "
pH (color)	12.6
Temperature	150° F.
C. D. (cathode)	50 amp./ft.^{2}
C. D. (anode)	50 " "
No agitation	

1. Sodium citrate plus limited amount of potassium ions shows greatest efficiency range with variable carbonate content at 6 oz./gal. (45.3% average efficiency), which is comparable to the greatest efficiency range of the rochelle salt bath at 8 oz./gal. (52.8% average cathode efficiency). The cathode efficiency of a potassium-sodium citrate-copper cyanide bath is approximately 7.5% less than for a rochelle salt bath under similar conditions.

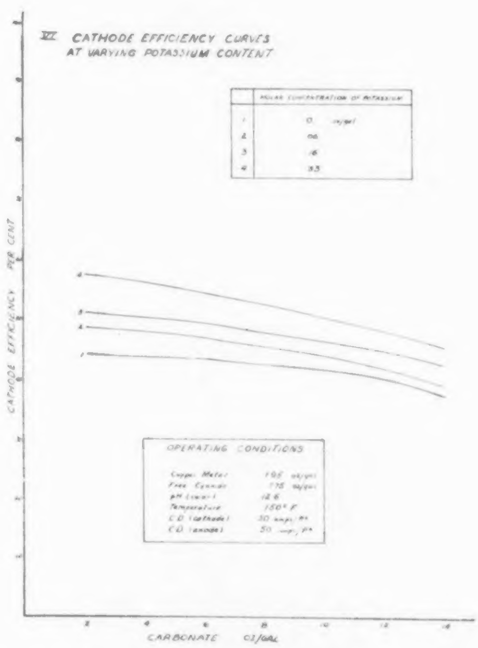
2. The character of cathode deposits from the citrate bath is definitely superior in appearance with greater luster and more uniformity in color and grain size, also less tendency toward burning or roughness.

3. With an anode current density of 50 amp. per sq. ft., anode efficiencies are 18.3% average lower in the citrate bath at 6 oz./gal. of sodium citrate than in the rochelle salt bath at 6 oz./gal. of rochelle salts under similar operating conditions.

4. Anode efficiency in the citrate bath exceeds the cathode efficiency by an average of 6% at 6 oz./gal. of sodium citrate, whereas in the rochelle salt bath, the anode efficiency exceeds the cathode by 14.7% at 8 oz./gal. of rochelle salts. There will be less build up of metal in the citrate bath. In fact, it should nearly balance with equal cathode and anode areas. The normal loss by drag-out will be compensated by the slight excess in anode efficiency.



Graphs VI. Anode efficiency curves at varying potassium content.



Graphs VI. Cathode efficiency curves at varying potassium content.

PART II

Effect of Citrate and Potassium on Cathode and Anode Efficiencies

In order to determine whether potassium or citrate exerted more effect on anode and cathode efficiencies of a copper cyanide plating solution, further experiments were carried on varying the potassium content in the absence of citrate and in the presence of citrate. As in the previous work,

the carbonate content was varied from 2-14 oz./gal. The same experimental procedure as in Part I was used.

The effect of variable citrate content was investigated using two solutions, one in which the citrate content was equivalent to 1.84 oz./gal. of sodium citrate, and one in which the citrate content was equivalent to 6 oz./gal. of sodium citrate. In this case the potassium content of the baths was constant, the concentration of potassium being 0.16 molar. The composition of the solution from which the efficiency tests were made is given below:

Copper metal	1.95 oz./gal.
Free cyanide	0.775 " "
pH (color)	12.6

The potassium content of the solutions was introduced as potassium citrate, 2.3 oz./gal., forming the equivalent of 1.84 oz./gal. of sodium citrate, and at the same time making the solution 0.16 molar in potassium. For the series in which the equivalent of 6 oz./gal. of sodium citrate was present, enough sodium citrate was added to furnish the desired concentration.

TABLE V

Cathode and Anode Efficiencies with Citrate at Varying Potassium Content

Series No.	Carbonate oz./gal.	Citrate as Sod. Cit.	Molar Conc. of Potassium	Cathode Effic. Per Cent	Anode Effic. Per Cent
1	4	6 oz./gal.	0	44.5	47.8
1	8	6 " "	0	42.0	41.4
1	11	6 " "	0	43.8	42.4
1	14	6 " "	0	40.3	41.0
Average				42.7	43.1
2	2	6 oz./gal.	0.06	48.7	66.4
2	5	6 " "	0.06	49.3	50.0
2	8	6 " "	0.06	41.9	47.8
2	11	6 " "	0.06	44.8	42.5
2	14	6 " "	0.06	41.9	50.0
Average				45.3	51.3
3	2	6 oz./gal.	0.16	50.4	47.0
3	5	6 " "	0.16	50.6	38.7
3	8	6 " "	0.16	47.4	35.5
3	11	6 " "	0.16	46.3	38.5
3	14	6 " "	0.16	43.4	36.7
Average				47.6	39.3
4	4	6 oz./gal	0.33	53.3	47.4
4	8	6 " "	0.33	52.2	40.5
4	11	6 " "	0.33	52.9	45.8
4	14	6 " "	0.33	47.0	41.6
Average				51.3	43.8
5	2	1.84 oz./gal.	0.16	56.6	37.1
5	5	1.84 " "	0.16	50.9	28.8
5	8	1.84 " "	0.16	51.0	26.0
5	11	1.84 " "	0.16	48.6	25.9
5	14	1.84 " "	0.16	45.3	22.8
Average				50.5	28.1
		Rochelle Salts			
6	2	6 oz./gal. R.S.	0.16	51.3	79.3
6	5	6 " " "	0.16	56.5	75.0
6	8	6 " " "	0.16	49.6	65.0
6	11	6 " " "	0.16	54.4	68.7
6	14	6 " " "	0.16	48.0	60.2
Average				51.9	69.6

Following are the figures on the cathode and anode efficiencies on solutions showing the effect of variable citrate and potassium concentration.

From the figures given above, the increase in citrate appears to materially increase anode efficiency. With no factor but the citrate content varied, anode efficiencies increase over 10% with an increase of approximately 4 oz./gal. of sodium citrate. Cathode efficiencies, as can be seen, decrease approximately 3% with the increase in citrate. It thus becomes apparent that anode behavior is more strongly influenced than cathode behavior by variation in the citrate content of the solution.

Graph No. V—Cathode and Anode—shows comparison of efficiency curves of solutions with variation in potassium content with citrate present. The effect of increasing citrate as sodium citrate from 1.84 to 6 oz./gal. at potassium concentration of 0.16 molar shows that additional citrate depresses somewhat the cathode efficiency and increases the anode efficiency considerably. In the presence of citrate, an increase of potassium concentration results in increased cathode efficiency as the potassium is increased.

The effect of increased potassium content on the anode efficiency shows more extensive variations. The effect of increased citrate content in increasing the anode efficiency is notable. The comparisons of anode curve No. 3 and No. 5 are conclusive in this respect. It appears when anode curves No. 1 and No. 2 are compared that a solution 0.06 molar in potassium will provide greater efficiency than a solution containing no potassium at all. Curve No. 2 is indicative of this. Anode curve No. 4 which represents a solution having a conc. of 0.33 M potassium shows little difference from the curve No. 1 which represents a solution with no potassium. Yet the anode efficiency of No. 4 is higher than No. 3 which has approximately one half the potassium concentration of No. 4. The fact that the solution represented by curve No. 4 was built up with citric acid, adjusted with potassium hydroxide and cyanide may result in a different anode action. The trend shown here is that an increase of potassium ion concentration above 0.06 molar does not improve the anode efficiency.

As the next step in investigating anode and cathode efficiencies, the effect of variable potassium in the absence of citrate was determined. The tendencies of four solutions were investigated, one bath with no potassium, a bath 0.06 molar in potassium, a bath 0.16 molar in potassium, and a bath 0.33 molar in potassium.

The solution from which the efficiency tests were run had the following basic composition:

Copper metal	1.95 oz./gal.
Free cyanide	0.775 " "
pH (color)	12.6

The bath with no potassium was prepared from copper cyanide, sodium cyanide, and sodium hydroxide (to adjust the pH).

The solution 0.06 molar in potassium was prepared from copper cyanide, sodium cyanide, and potassium hydroxide (0.5 oz./gal.) to furnish the proper concentration of potassium.

The solution 0.16 molar in potassium was prepared from copper cyanide, sodium cyanide, potassium hydroxide (0.5 oz./gal.) and 0.92 oz./gal. of potassium carbonate to make

the bath 0.16 molar in potassium. Further additions of carbonates in the bath were made with sodium carbonate.

The solution 0.33 molar in potassium was furnished its potassium content through potassium cyanide and potassium hydroxide in a like manner as shown above.

Following are the figures on the efficiency runs of these four solutions.

TABLE VI

Effect of Variable Potassium Content

No.	Carbonate oz./gal.	Cathode Efficiencies of Solution with Molar Conc. of Potassium of: 0	0.06	0.16	0.33	Anode Efficiencies of Solution with Molar Conc. of Pot. of: 0	0.06	0.16	0.33
1	2	44	48.8	51.9	58.3	11.7	20.3	21.1	21.2
2	5	43.8	47.6	49.6	54	13.1	15.5	16.1	16.7
3	8	41.6	45.6	46.8	52.1	13.3	13.1	13.4	12.7
4	11	41.2	41.5	45.4	49.5	8.7	11.9	11.6	12.5
5	14	38	39.6	43.1	47.2	7.1	11.2	12.7	14.5
Average		41.7	44.6	47.4	52.2	10.8	14.4	14.9	15.5

Cathode efficiencies under the conditions above show a steady, appreciable increase with increasing potassium content of the solution. From a bath with no potassium to a bath of similar composition but 0.33 molar in potassium, the cathode efficiencies average approximately a 10% increase.

The anode efficiencies increase only slightly with an increase in the potassium content of the solution, the largest increase appearing between the solution with no potassium and the solution 0.06 molar in potassium. The increase here is approximately 4%. Increasing the concentration of potassium above 0.06 molar in the solution results in only slightly increased anode efficiencies, an increase of 1.1% being shown for an increase in potassium concentration of from 0.06 to 0.33 molar.

Above are curves which attempt to bring out visually the differences in efficiencies, anode and cathode, which occur under varying concentrations of potassium.

The curves No. VI cathode and VI anode represent efficiency curves, cathode and anode respectively, of copper cyanide solutions with varying potassium content in the absence of citrate. These curves correspond to the figures shown in Table VI. From the cathode efficiency curves, it can be seen that the four curves resemble each other in configuration very closely, with the increase in potassium content determining the order of ascendency. These curves would seem to indicate that the increase in carbonate content of the four solutions brings about a relatively constant decrease in efficiency.

The anode curves for the corresponding solutions show that the three solutions with variable potassium content have curves which are fairly similar; the bath with no potassium, however, shows an anode efficiency curve which is almost the inverse of the other three. Again the position of the four curves is determined by the increasing concentration of potassium in the four solutions.

Conclusions—Part II

The following conditions are those upon which the conclusions given below are based:

Copper metal	1.95 oz./gal.
Free cyanide	0.750 "
pH (color)	12.6
Temperature	150° F
C. D. (cathode)	50 amp./ft.^{2}
C. D. (anode)	50 amp./ft.^{2}
No agitation	

1. Increased potassium ion concentration from 0-0.33 molar results in steady increase in cathode efficiency. This increase in cathode efficiency is independent of citrate radical concentration.

2. When a potassium concentration of 0.16 molar or higher is present, a solution has approximately as high an average cathode efficiency as a rochelle salt-copper cyanide solution which has a molar concentration of 0.16 M potassium at 6 oz./gal. of rochelle salts.

3. At 0.16 molar concentration of potassium, an increase of citrate content from 1.84 oz./gal. (as sodium citrate) does not increase the cathode efficiency. In fact, there is a lowering of efficiency. The opposite effect is present at the anode. The increase in citrate concentration results in greatly increased anode efficiency.

4. The anode efficiency of the rochelle salt-cyanide copper bath is much higher than anything obtainable with the use of citrate.

5. In summary, it appears that the anode curves show the importance of the citrate content in determining the anode efficiency. The cathode curves for this series show the importance of potassium as the determining factor for cathode efficiency. There appears to be a balance in citrate and potassium concentration which will provide sufficiently high cathode and anode efficiencies without sacrificing one for the other. Under the operating conditions used here it appears that a molar concentration of 0.06 M in potassium with 6 oz./gal. of citrate, as sodium citrate, will give cathode and anode efficiencies which balance quite closely. The potassium ion concentration of such a solution should be readily obtainable. A higher potassium concentration would require the use of potassium cyanide to produce the required potassium concentration. All potassium salts are limited in availability. However, the small amount of potassium hydroxide required for control of pH should be obtainable and would furnish the necessary quantity to maintain higher cathode efficiencies.

New Data for Practical Design of Ventilation for Electroplating†

BY WILLIAM P. BATTISTA, THEODORE HATCH AND LEONARD GREENBURG

Division of Industrial Hygiene, New York State Department of Labor

SUMMARY—It is essential in connection with some of the electrolytic processes now used in many industries to provide adequate means of protection for the health of the worker. The danger lies chiefly in the exposure to irritating and toxic mists, gases and vapors dispersed from the electrolytic solutions. The design of ventilating systems which will most effectively control these atmospheric contaminants is a practical problem for factory management, one which assumes added significance with the ever-increasing use of electroplating and anodizing techniques in the manufacture of precision parts and machinery in modern industry. Several of these electrochemical deposition processes comprise important present-day procedures in the production of aircraft, airplane engines and other equipment vital to our defense needs.

Factors to be considered in the design of efficient ventilation for plating and anodizing processes include current density, plating voltage, solution temperature and tank size, as well as the chemical nature of the solutions employed. Because of the fact that practically all elecrolytic tanks are proportioned on conventional shapes and dimensions, certain basic fundamentals of design are applicable to all the processes wherein the dissemination of contaminants makes control by ventilation essential.

This article concerns itself with certain important fundamentals of tank ventilation with reference to proportion and design. The approach employed utilizes the usual type of ventilation practice for the control of chromic acid mists as a basis for discussion. Features of this practice have been selected as a basis for study since the toxicity of chromic acid makes it essential that these mists be controlled with a high degree of completeness, constituting in this respect a severe test of ventilation control.

Briefly, the information given here may be summarized as follows:

(1) In usual practice, objectionable atmospheric contamination is removed from an electroplating tank by means of lateral exhaust ventilation through slotted air chambers or ducts along the two long sides of the tank. The capacity of the exhaust system is calculated on the assumption that the required rate of ventilation varies directly with the tank width.

(2) Accepting the principle that a given minimum air velocity is required at the center of the electrolytic surface for effective control on tanks of all widths, the results of tests indicate that the rate of ventilation should vary approximately with the 1.6 power of the tank width, rather than directly with the width.

(3) The rate of ventilation through the exhaust slots should be constant throughout the length of the tank. This is seldom obtained in practice, however, because of the design and size of the slotted chambers commonly used and the way in which they are installed in relation to the tank and fan.

(4) Because of limited space for the installation of the ventilating ducts, it is generally not possible to employ an ideal design. In contrast to present practice however, greater uniformity of ventilation throughout the length of the tank can be obtained by the use of manifolds of uniform cross-section together with distributing vanes as specified herein.

CHROMIUM plating creates a serious health hazard through the exposure of operators to the chromic acid mist dispersed from the electrolytic solution. Control of this hazard is commonly accomplished by means of lateral exhaust ventilation through slots extending along the two long sides of the plating tank. Suitable manifolds and ducts connect the two slots to the exhaust fan and discharge pipe. The rate of ventilation recommended by several investigators[1, 2] to reduce the concentration of chromic acid to the safe limit is determined by the relation $Q = 100\ LW$, where Q = total rate of ventilation in cfm, L = length of tank in ft, and W = width of tank in ft.

It is clear that the rate of ventilation must vary with tank width in such a way that a required minimum air velocity will be created at the center of the tank in all cases. According to the above equation, the relationship is taken to be a direct one; that is to say, the air velocity outward along the center line of the slot is assumed to vary inversely with the distance from the slot. DallaValle's studies[3] of the velocity distribution around exhaust openings, however, have shown that the center line velocity in front of a suction opening is inversely proportional to an exponential value of the distance from the slot. This exponent was found to have a value greater than unity. In view of this, some question may be raised with respect to the correctness of the above equation for tanks of different widths. The relationship has been investigated by the authors and the velocity contours and center line velocity equation obtained for a typical exhaust system on plating tanks. The results of this study are reported here.

In addition to the necessity for a proper relationship between rate of ventilation and tank width, it is clear that the air flow per unit of tank length should be reasonably constant throughout the entire length. This follows from the most elementary consideration of the ventilation requirements. It is not an easy matter, however, to obtain a uniform distribution of flow because space limitations often

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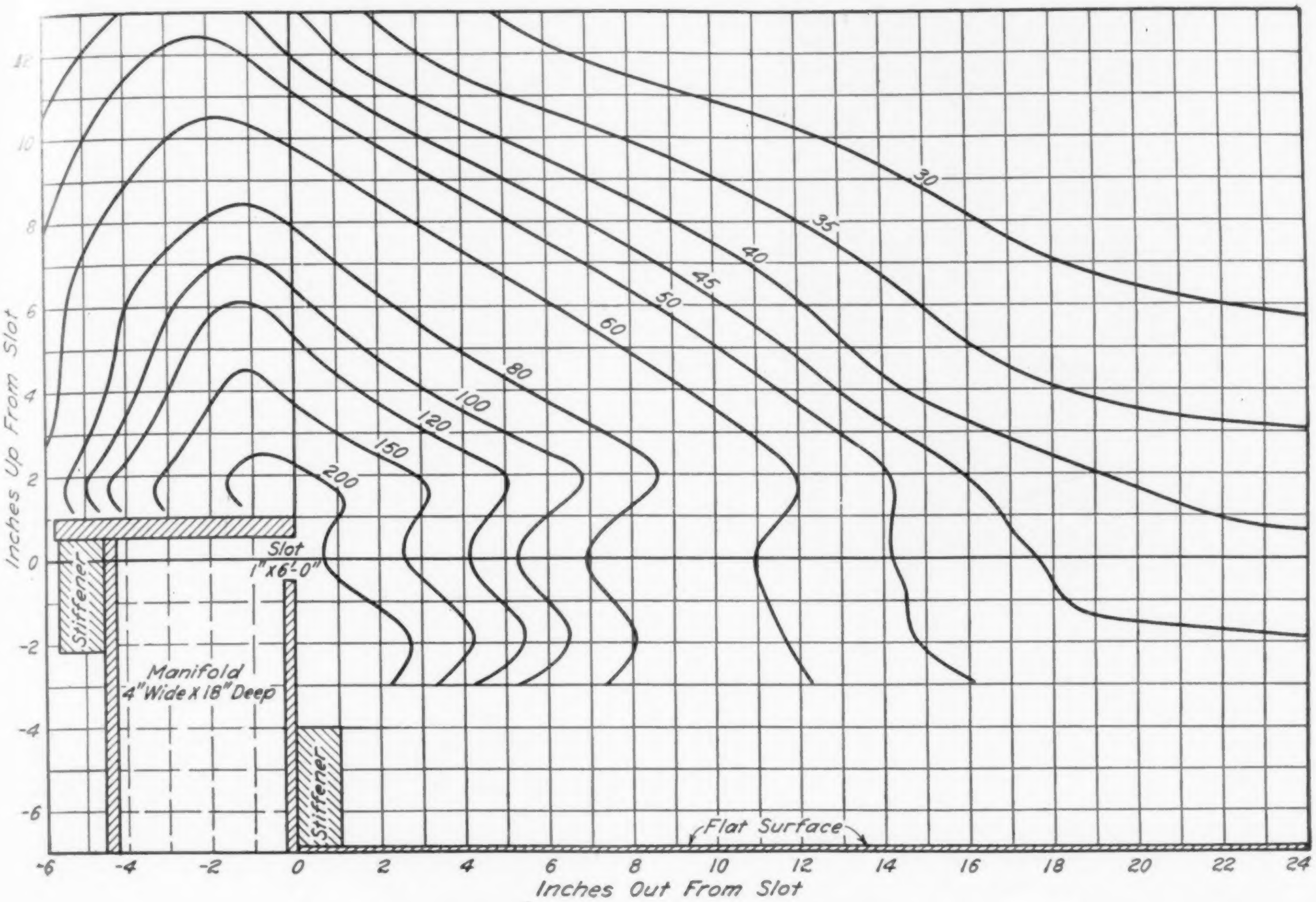

Fig. 1—Velocity contours for plating tank exhaust slot.

do not permit the use of the elaborate exhaust piping which is required. In practice, there is need for a simple and compact ventilating system which, with reasonable power cost, will provide a constant rate of ventilation for each foot of tank length. A second objective of the present study therefore was to develop the design requirements for such a system.

Two plating tanks of different widths may be said to have equally effective ventilation when the velocity contours over the centers of the two tanks have the same values. Hence, the rate of ventilation must increase with tank width in accordance with the relationship which governs the change in velocity with distance outward from the slot.

Ventilation Rate and Tank Width

Theoretically, the velocity distribution may be considered from the standpoint of two limiting conditions: (1) a slot of infinite length or, in effect, a line source of suction of constant value throughout its length; and (2) a suction opening of such limited dimensions that the conditions approach those of a point source of suction. In the first case wherein an unobstructed line of equal suction throughout its length is assumed, the velocity contour surfaces will take the form of a series of concentric cylinders with the line source as an axis. Under this condition, the air velocity in the space around the line source will vary directly with the distance away from the line since the surface area of cylinders of equal length varies directly with their radii. Applying this to the ventilation of a plating tank, the following relation could be written:

$$Q = KLW \text{ or } Q/L = KW$$

where Q = air volume per unit time;
K = a constant;
L = tank length;
W = tank width.

This equation has the same form as the one now in use. In the second limiting case wherein approximately a

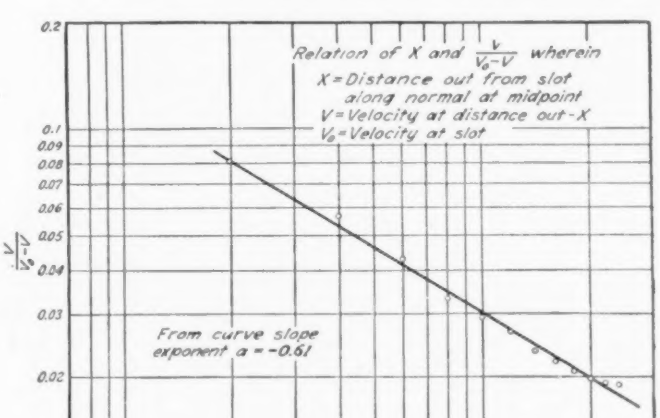

Fig. 2—Relation between center line velocity and distance outward from slot.

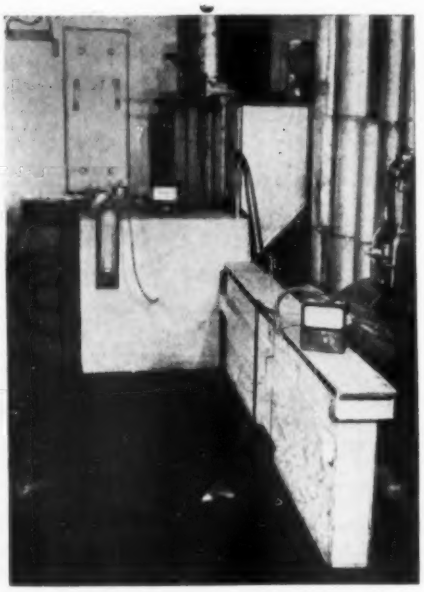

Fig. 3—The apparatus for studying ventilation of electroplating tanks.

point source of suction in an unobstructed space is assumed, the velocity contour surfaces will take the form of a series of concentric spheres. The surface areas of these contours will vary with the square of their radii, thus:

$$A = KR^2$$

where A = surface area of spherical contour
R = radius of contour spheres

Considering R in terms of tank width, the relation between rate of ventilation and tank width becomes

$$Q/L = KW^2$$

The velocity distribution in the actual case of an exhaust slot on a plating tank does not conform to either of these limiting cases, since the suction opening is not unobstructed. Air cannot be drawn from the space occupied by the tank and, as a consequence, the contours in the immediate neighborhood of the obstructing surface are displaced in an outward direction because of the flange action of the obstruction. Thus, the exponent will be less than 1.0 and 2.0 for the line and point sources respectively. For tanks of relatively great length, the exponent of the velocity-distance relationship will therefore be less than 1.0 whereas for short tanks (approaching a point source) the exponent will be between 1.0 and 2.0.

DallaValle[3] has developed the following general equation for the relation between the center line velocity V at various distances X from the exhaust opening and the velocity V_0 through the opening:

$$\frac{V}{V_0 - V} = KX^{-a}$$

A determination of the exact value of the exponent a for a typical exhaust slot was made by the authors on apparatus described later in this report (Fig. 3 and Arrangement E in Fig. 4). Velocity measurements were taken by means of the thermal anemometer in a vertical plane normal to the midpoint of a horizontal slot 6 ft. long by 1 in. wide having an approximately uniform rate of air flow throughout its length. A smooth flat surface placed horizontally 7 in. below the slot simulated the electrolytic surface in a plating tank.

Velocity contour curves according to accepted procedure[3] corresponding to the common slot velocity of 2000 fpm for chromium plating are shown in Fig. 1. (These contours are for one slot only. For two slots on opposite sides of the tank, the combined contours would be equivalent to the vectorial sum of the contours shown in Fig. 1 and a reverse set of the same relative values established by the second slot.) Center line velocity values, outward from the slot, were obtained from these curves and plotted according to DallaValle's general equation in Fig. 2. The slope of the straight line resulting from this plot indicates a value of the exponent a of —0.61 for the 6 ft. slot.

Thus, the exponent is less than the theoretical minimum of 1.0 for a line source of suction, which means that the rate of ventilation per square foot of tank area decreases with increasing tank width. As explained above, this departure from the theoretical minimum is explained by the flange effect of the horizontal surface below the slot which tends to displace the velocity contours in an outward direction.

In practice, however, plating tanks do not vary greatly in length and the exponential value of —0.61 may therefore

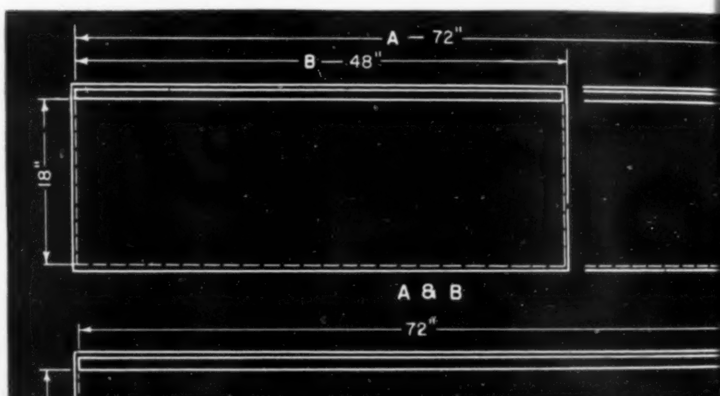

Fig. 4—Side views of test manifolds.

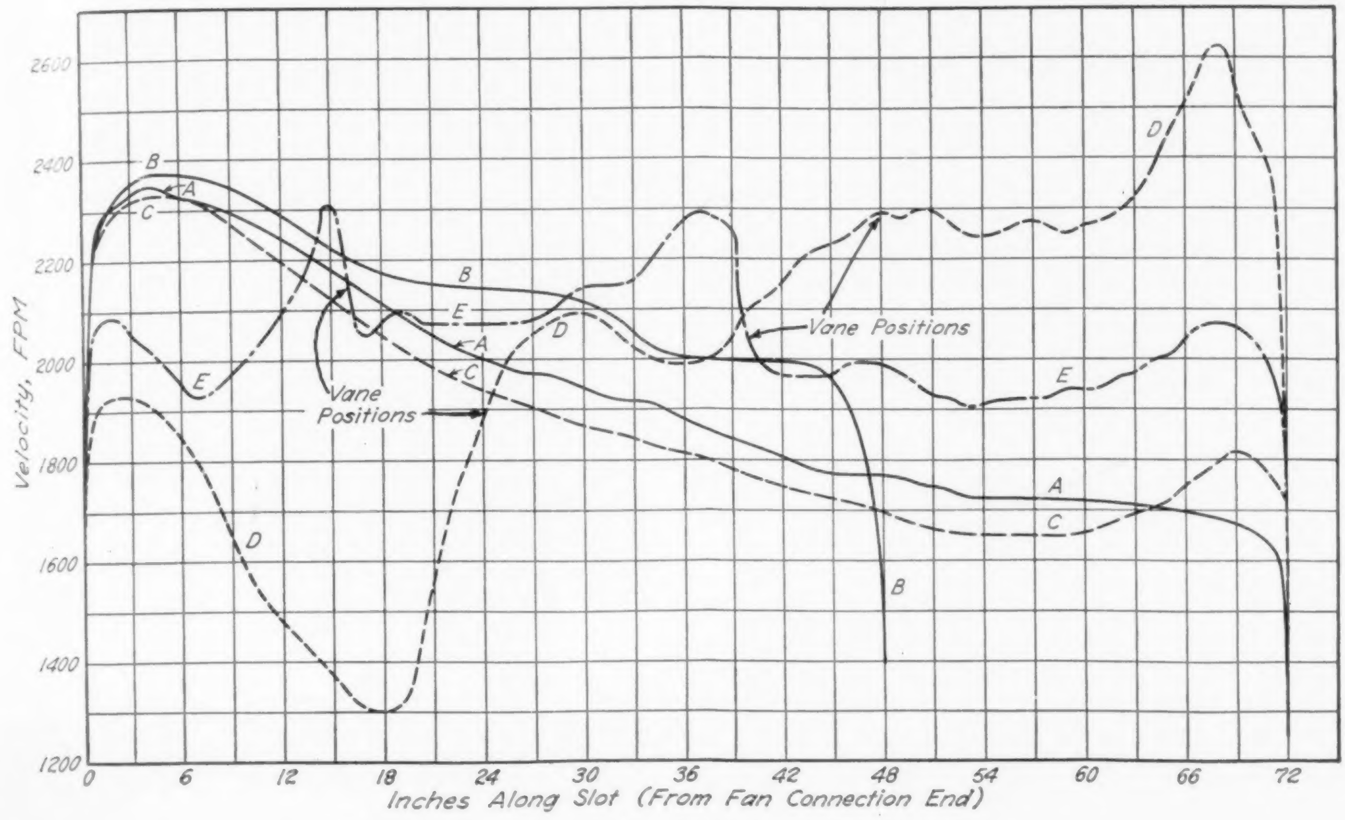

Fig. 5—Velocity distribution along slot for the various test manifolds.

be employed in the equation $Q/L = KW^{0.61}$ to determine the rate of ventilation in relation to tank width for most plating tank problems. (*Note*—The velocity distribution characteristics of exhaust slots have been subjected to more elaborate dimensional analysis by Silverman[4], the results of which will provide valuable information relative to the ventilation requirements for the many different process tanks encountered in industry.)

A more complete form of the equation for determining the rate of ventilation for electroplating tanks than that given in the preceding paragraph is:

$$Q/L = K^1 V W^{0.61}$$

where Q = total rate of ventilation, cfm;

L = total length of slot, feet;

V = controlling minimum velocity over the tank, fpm;

W = tank width, feet;

K^1 = constant, the value of which varies with the tank shape and with the shape and location of the exhaust slots. For slots on the two long sides of the tank, K^1 will be smaller than for one slot only since the velocity over the center of the tank with two slots is the vectorial sum of the velocities established by both slots.

Further experimental work is required to determine the proper values of V and K^1 for various types of electroplating tanks.

The limited data on ventilation requirements for chromium plating tanks of different widths[1, 2] are not sufficient to show the correctness of the new or earlier equations. It is to be noted, however, that the rate of ventilation and the power consumption for wide tanks are greater when determined by the proposed relationship than by the equation now in use. Thus, if a rate of ventilation of 100 cfm per sq. ft. of tank area is necessary for a tank 3 ft. wide, the exponential formula would require a rate of 120 cfm per sq. ft. for a tank 4 ft. in width. In the interests of economy in design, therefore, further study of the ventilation requirements on plating tanks is needed, particularly with reference to the value of the constant K.

Design of Exhaust Manifold

The need for a uniform rate of ventilation through the entire length of the exhaust slot has been pointed out. This is most nearly secured by using a slotted plenum chamber of relatively great cross-sectional area in which the negative pressure is substantially uniform regardless of the location of the fan connection. Another method is to provide numerous pipe connections from the fan to equally spaced points along a slotted duct. Neither scheme is practical because of the limited space generally available around plating tanks. A tapered duct with a slot of uniform width with the fan connected to the larger end is found in practice to give a non-uniform distribution of flow. The use of an adjustable tapered slot is objectionable because the slot opening is seldom properly adjusted or fixed permanently in the correct position.

The problem becomes one of designing a compact manifold of simple construction which will provide a reasonably uniform distribution of flow and does not occupy too much space. The simplest design is one which employs a manifold of uniform cross-section on the two long sides of the tank with a common exhaust chamber and fan connection at one end. The cross-sectional dimensions of the manifold should

be as large as possible in order to approach the effect of a plenum chamber. In accordance with common practice in ventilation, the manifold may be provided with internal vanes, as required, to insure a uniform distribution of flow. The design requirements of such a manifold are developed below.

The test apparatus, shown in Fig. 3, was fabricated of 1/4 in. plywood and 1/2 in. lumber with stiffening members, as required. Internal dimensions of the manifold were 72 in. long, 18 in. deep and 4 in. wide. A 1 in. slot ran the full length of the manifold at the top of one side, thus providing an air intake area of 1/2 sq. ft. A plywood box 30 in. long, 27 in. high and 12 in. wide was joined at right angles to the manifold to serve as an exhaust plenum chamber. The fan was connected to this plenum at the rear top corner diagonally remote from the manifold with common 8 in. pipe. The additional height of plenum over that of the manifold served to simulate the air flow effect of the tapered elbow ordinarily used in practice to connect the fan pipe to the two manifolds.

A blast gate on the exhaust fan was adjusted throughout the tests so that the average air velocity through the slot was 2000 fpm.

Velocities at the slot were measured with a direct reading air velocity meter using the appropriate attachment. Readings were made at the top, middle and bottom of the slot for each 1 in. interval along the slot. These were averaged to obtain one set of readings for the 1 in. slot opening.

The first series of velocity readings were obtained with the simple manifold (Fig. 4*A*). The results are plotted as Curve *A* in Fig. 5 and reveal a marked decrease in slot velocity with distance from the exhaust end of the duct. In the second test, the manifold was shortened to 4 ft., thus making its cross-sectional dimensions relatively greater and more nearly approaching the plenum chamber effect (Fig. 4*B*). The velocity distribution, plotted as Curve *B* in Fig. 5, also shows a marked non-uniformity along the slot. The results of these two tests are in agreement with past experience and indicate that a simple uniform manifold of the limited dimensions permitted in practice is not acceptable. A single curved vane at the remote end of the manifold (Fig. 4*C*) served to increase the flow in this region, as shown in Curve *C* in Fig. 5, but did not significantly improve the distribution of flow through the slot as a whole. The results of this test indicate clearly the need for additional distributing vanes.

Accordingly, two more curved partitions were installed in such a way as to divide the manifold into three separate sections, as shown in Fig. 4*D* and 4*E*. In Arrangement D, the vanes were equally spaced along the slot and arbitrarily located vertically so as to provide the greatest cross-sectional area in the bottom section which draws air from the remote end. The resulting velocity distribution, shown by Curve *D* in Fig. 5, indicates that too much air was drawn through the bottom section. Consequently, the vanes were relocated, as in Fig. 4*E*, to provide equal vertical spacing and a varying distribution along the slot according to simple fractional proportions. With the exception of minor disturbances in flow in close proximity to the vanes, this arrangement provides a reasonably uniform slot velocity (Curve *E*, Fig. 5). Undoubtedly, further investigation would show more desirable vane arrangements, but the

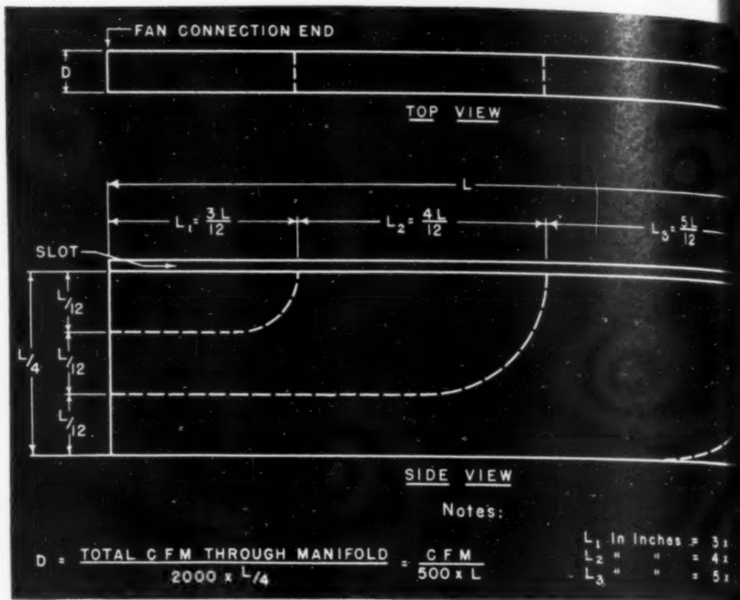

Fig. 6—Recommended design of exhaust manifolds for uniform distribution of flow.

practical features—and particularly the simplicity—of Arrangement *E* recommends it. The final design, with the proportions adjusted to require only the simplest design calculations, is shown in Fig. 6. The arrangement shown in Fig. 6 may be employed for manifolds of any reasonable length, provided all dimensions are determined in the proportions shown. For long tanks this requires considerable depth to the manifold. A more compact arrangement for long tanks is given by installing fan connections at both ends of the tank thus making the effective manifold length for each fan one-half the tank length.

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How the Use of Hydrofluoric Acid for Hot-Dip Galvanizing and Hot-Dip Tinning Was First Discovered

IN A highly technical and scientific age like the present one, almost everything is taken for granted. Every now and then some incident crops up that reminds us that the early pioneers in the fields of hot-dip galvanizing and hot-dip tinning struggled around in the dark trying to find some of the simplest things which are standard practice today. One of these with an interesting story behind it is the use of hydrofluoric acid for cleaning work for hot-dip galvanizing and hot-dip tinning.

The discovery of hydrofluoric acid for cleaning cast iron

(*Concluded on page 428*)

Silver Recovery from Hypo Solutions

By FRED HERR

Los Angeles, Cal.

THE silver extraction process now used by the laboratory department of Metro-Goldwyn-Mayer Studios at Culver City, Calif., results in the recovery of more than $100,000 worth of silver a year from hypo solution. This represents an increase of more than 39% over the amount that had been recovered by previous methods, for prior to the introduction of the present process much of the silver content of hypo solution was lost for want of an effective extraction technique.

In addition to the profit on the recovered silver, the process now employed effects considerable saving in the hypo bills. In the past, entire batches of hypo had to be discarded at frequent intervals and replaced with new supplies. This was due to the diluting and weakening effect of the unrecovered silver bromide. Today the studio discards no hypo at all. Instead of mixing from 5,000 to 6,000 gallons of fresh solution every week or so, the laboratory department now uses and re-uses the same supply, merely replenishing it with some 400 gallons of fresh solution daily.

All film used in motion picture production contains silver in emulsion in the form of silver bromide. In contacting the hypo solution in the battery of M.G.M. development tanks, the film deposits silver compound into the hypo. Each million feet of film contains 1400 ounces of silver. The greatest portion of this is left behind in the developer. On busy days as much as 700,000 feet of film is developed at this studio, placing the process of silver recovery in the field of big business.

In the past the studio had tried various methods designed to recover the silver as well as to save on hypo costs. All former methods, however, were found inadequate because of the limited amount of silver which could be recovered through them and also because of the detrimental effect on the solution.

M.G.M. currently uses an extraction method that involves the use of recovery chambers equipped with carbon anode and stainless steel cathode plates immersed in the solution. The process has demonstrated its effectiveness over a period of years. It was originated by Dr. K. Hickman of the Eastman Kodak Co. in 1930, tested in the Eastman laboratories at Rochester, N. Y., and submitted to the Metro-Goldwyn-Mayer organization in 1931. The film company installed three so-called "recovery cells" as an experiment and found the results so satisfactory that it subsequently increased the number of cells to eight, the number now in use in the laboratory silver recovery department.

The present elaborate system of gravity flows, recovery cells, solution filters, replenishment vats, silver removal benches and developer setups is the outgrowth of the original trio of experimental cells.

Metro-Goldwyn-Mayer ranks among the world's largest motion picture studios. Its developing department handles film in amounts ranging from as little as 2,000 to as high as 700,000 feet per day. In the past only about 50% of the silver was recovered and the extraction process then in use had the effect of weakening the hypo to such degree that it had frequently to be replaced. Considering that 6000 gallons of hypo are used daily at the studio, the frequent replacements represented considerable expense.

The silver recovery division is housed in a two-story laboratory building at the southeastern corner of the huge M.G.M. lot, opposite the costume and props buildings. The recovery room is 40 by 72 feet in dimension. Its location on the ground floor is by design, for one of the features of the present recovery system is gravity flow of the hypo solution. The 6,000 gallons are kept in almost constant circulation from the roof, through the developer tanks, down to the recovery cells, and back to the roof by pump.

The hypo starts its round trip from a 700-gallon storage tank on the roof of the two-story laboratory building. From the tank it flows by gravity at an average rate of 25 G.P.M. to the second floor, where it passes through the 14 development tanks that occupy a section of the second floor. It is there that the film deposits silver into the hypo solution in proportions of some 89% of the 1400 ounces present in each million feet of film.

From the developers the hypo flows in a slow slop-over manner at a carefully calculated rate of slightly more than one and two-thirds gallon per minute from each developing machine. The total rate of slop-over from the 14 machines is calculated exactly to balance the 25-gallon-per-minute flow from the roof tank. The slop-over from all developers converges at the south end of the second-floor, enters a master channel and drops to the recovery room on the first floor.

On the first floor the hypo, now laden heavily with silver bromide, gelatin and other chemical by-products, flows through a manifold into the upper part of a filter tank. The filtering process is an added precaution used to assure the removal of obvious impurities which the hypo may have picked up in its journey from the roof. The filtering process is simple; entering the top of the filter tank, the liquid drops into cloth bags resembling over-sized socks. The straining effect, as the solution slowly trickles through the bottom of the bags, leaves behind impurities, which are caught in an adjoining muck tank.

From the filter the hypo passes into a manifold from which feeder lines finger out to each of the eight recovery cells. The cells are ranged in a single row behind the filter. The cells (so-called for want of a more appropriate name) vaguely resemble huge storage batteries with open tops. They consist of wooden cabinets 3 feet long, 2 wide and 2½ high. Each cell contains 11 carbon anodes and 10 stainless steel cathode plates, which are fitted into slots

that separate each anode from its complementing cathode by a measured distance. Provision for free circulation of the hypo is made at top and bottom of the plates. The plates are electrically charged. Solution entering one side of the cell, contacts the cathodes and anodes and leaves the silver behind in the form of a soft, mushy deposit on the cathode plates.

The silver hardens when the plates are removed from the cell. The hardened deposits are dislodged from the plates by jarring the cathodes against a wooden bench, called a stripping bench. The silver, now in the form of hard, flaky particles, falls through slits in the bench into a container underneath.

The recovered material is composed of approximately 99% silver and 1% gelatin. To melt and mould the flakes into ingots for convenient storing would violate the government's regulation against hoarding precious metal. Flake silver, however, may be stored with impunity. The studio's practice is to store the flakes until a substantial supply has accumulated and then sell it to a silver smelter. The amount of silver recovered at M.G.M. averages 250,000 ounces a year, which has a value of more than $100,000.

From the eight recovery cells the hypo, now freed of its silver content and other impurities, is led into a mixing vat for replenishment. Replacement is at the rate of 400 gallons a day, for which purpose 1000 pounds of sodium thiosulfate crystals are added to the solution remaining in the mixing basin. From this container the replenished solution is passed into a collecting tank in the recovery room, from which it is pumped to the master storage tank on the roof.

The 400 gallons added daily represent the total new solution required under the present system. This total of less than 3,000 gallons of new solution per week contrasts with past procedure under which the entire 6,000 gallons had to be replaced each week, sometimes oftener, plus the added expense of tank wagons to haul away the discarded hypo. Today no hypo is hauled away at the M.G.M. Studios. Some waste and loss results from slop-over and occasional leakage, but, on the whole, the same batch of hypo, replenished regularly, has been used for a number of years. The only labor involved in preparing solution consists of about two hours' work each day by one man whose duty it is to add the sodium thiosulfate to the replenishment basin.

By the old method, 700 gallons of hypo were required to develop 100,000 feet of film. The average was so low because the silver extraction method used at that time often made it necessary to throw away an entire batch of hypo and mix a new supply. Under the current replenishment program, 700 gallons of hypo are sufficient to develop from 600,000 to 700,000 feet of film. Under former systems a "high" hypo resulted, which reduced the acidity of the solution and built up the silver content. The present method not only results in the recovery of more silver—89.2% as compared with 50%—but makes for more uniformity of standard and sustained quality of the hypo.

Indicative of the effectiveness of the process is the fact that 1250 of the 1400 ounces of silver present in each million feet of film is recovered. The circulation method also makes possible better control of temperature in the hypo and results in less variation in chemical reaction. It has been found desirable at M.G.M. to maintain temperature at about 65° F., for under former systems in use at this studio, temperature control and maintenance of uniform temperatures in the hypo were difficult. It was not unusual for hypo to start with an original temperature of 40° F. and rise to 60 and even 70 degrees. The present system, being electrically operated, makes possible automatic control of temperature to any desired degree.

(Concluded from page 426)

sinks was related to the writer as follows by Joseph P. Cattie, President of Joseph P. Cattie & Brothers, Philadelphia, Pa. In a recent friendly interview with the writer, Mr. Cattie said—

"The first use of hydrofluoric acid for galvanizing and tinning I believe was in my father's shop in Brooklyn. My father's name was Jules Cattie. He was born in New York, and he was of French descent. He was a gold melter. He had four sons, Eugene, Joseph, Henry, and Nicholas. We boys worked in father's shop.

"One day a lot of lemon squeezers had to be done. They were made of malleable iron and had the name of Dunlap on them. He could not get the sand out of the letters in the name. Generally such work was well rumbled, and if pickled, it was pickled with oil of vitriol (sulphuric acid).

"One day a salesman from a chemical house came in while we were having trouble of getting the sand from the castings. This was way back in 1875, or there-about when not near so much was known about chemistry. My father asked him if he had an acid that would remove sand. He said, 'No', but before he left he mentioned he was going to call at a glass factory in Brooklyn. My father asked him how a glass factory used acid. He said they use it for etching glass, and removing sand.

"He left, and the next day my father called up the chemical house and asked them to send over 100 pounds of this hydrofluoric acid that would etch glass, and remove sand. He figured it should remove the sand from the castings. The first batch were pickled with a mixture of hydrofluoric acid and water like the regular acid. However a yellow scum formed on the casting and the tin would not take. It would not adhere to any part of the castings. He finally put them in a water tank to soak over night, and when he went for them in the morning the yellow scum had disappeared. Then he tried to tin them again without the scum, and they came out beautifully; every spot had a beautiful bright tin coating on it.

"The next day father called up the chemical house and asked them if they could not make him an acid that would not create the yellow scum on the castings. They finally were able to give him an acid that did not give the scum, and of course from then on there was no trouble. Later on he mixed the hydrofluoric acid with sulphuric and with muriatic acid, and from this discovery of my father's I believe that the modern practice of using hydrofluoric acid for cleaning castings for galvanizing and tinning, originated. There was no way of hot-dip tinning gray iron castings until this use of hydrofluoric acid was discovered. Casting acid, as it is called, is generally used today in all galvanizing and tinning plants for cleaning castings. I believe that this discovery of my father's was the first use of hydrofluoric acid for pickling sand from castings."

Wallace G. Imhoff
Vineland, N. J.
May, 29, 1941

American Silver Producers' Research Project

THE American Silver Producers' Research Project, sponsored by several of the leading silver producing companies in the United States, has completed a year of activity at the Bridgeport Plant of Handy & Harman. The Project, formerly located at the National Bureau of Standards, Washington, D. C., was reorganized June 1, 1940 and the research program and activities were transferred to the laboratories of Handy & Harman.

Container Linings

The field of electroplated coatings continues to show promise as an outlet for silver and the Project's pilot plating plant has been kept busy recently plating drums, pails and cans. At the present time one of the large can manufacturers is cooperating with the Project and a chemical supply house in the development of a silver lined can for packaging chemicals. This work, still in the early stages, is progressing satisfactorily and shows promise. Containers with a silver plated coating also have been packed with different commodities and some experimental units have been put into service. The results reported so far have varied and at the present time it has not been determined why containers, in some cases, have been quite satisfactory and in others, products have been contaminated.

One of the criticisms of silver lined containers appears to be that they do not give sufficiently superior advantages over those now in use to warrant the additional cost. For the general run of containers, this at present is undoubtedly the case, but it is not true for packaging some specialized products. In some instances, silver lined containers are being seriously considered and tested for packaging corrosive materials because the corrosion resistance of other metals and lacquers is not adequate.

Silver as a Substitute

In recent months the scarcity of many base metals has focused attention on the use of silver as a substitute for aluminum, nickel and tin. In places where sheet or foil aluminum has been used, for its corrosion resistance or high reflectivity, it is apparent that silver plating on available metals can be substituted since it possesses these qualities, for most purposes, to an even better degree than aluminum. Silver electrodeposits are being investigated as a substitute for nickel, as an undercoating for chromium plating. A series of experiments are under way to determine what advantages may be derived from the use of a corrosion-resistant electroplate of silver followed by a hard, wear-resistant chromium deposit. It is hoped that the two metals, aluminum and nickel, badly needed for National Defense, which are used in refrigerator shelves, ice cube trays, toasters, waffle irons and others, can be replaced at least in part by silver.

Strength of Tubing

The Project has also conducted experiments to determine the strength of extruded tubing made from a 3.5% silver—96.5% tin alloy. A bursting strength of 2500 pounds per square inch, or almost double that of pure tin, was obtained and this is apparently far in excess of any working pressure encountered in distilled water lines where this material is finding commercial use. Tests on threaded joints showed that the alloy had a tensile strength 25% greater than joints made with pure tin tubing. For certain installations it would seem feasible to use threaded connections in distilled water lines if the tubing were made of the silver-tin alloy. Both the 3.5% silver and 5% silver-tin alloys are finding applications as solders.

Solders

Interest continues in the possibilities of using lead-silver solders in place of the standard lead-tin alloys in automatic can making machines. There are many reasons for this and important among them is the fact that a large saving in the use of the strategic metal tin would result by this substitution. The 2½% silver-lead alloy is cheaper than the standard 50-50 solder and joints equally as satisfactory can be obtained. Many of the larger can manufacturers are actually carrying on experiments with these alloys to obtain data on actual operating conditions and service tests.

Corrosion Studies

The Silver Project's Fellowship at Lehigh University has continued with the corrosion studies of silver. The corrosion tests made include not only a study of different chemicals but also a study of a large number of different commercial products which may be manufactured in silver equipment or packaged in silver containers.

More recently a study has been started on the corrosion of silver-to-silver joints made with different silver brazing alloys. This is of particular interest in connection with the manufacture of silver lined chemical equipment. All of this work has been carried on in a thorough and comprehensive manner and much available data have been obtained.

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PLATING AND FINISHING
POLISHING — BUFFING
CLEANING — PICKLING
HOT DIP FINISHES

SHOP PROBLEMS

Tinning Practice

Q. We have been informed that there is a tinning flux available on the market which is non-acid, and is made ready for use by simple dilution with water.

Will you kindly give us any information you may have regarding this product.

A. I have not heard of such a material. From my practical experience covering many years, I do not believe that it is possible to flux without an acid salt of some kind. At one time I conducted very extensive research investigations and found that a neutral, or alkaline flux not only tended to cause peeling and flaking of the coating, but also tended to fill the flux solution with precipitated alkaline salts, such as oxides and hydroxides. If there is such a compound that can be mixed with water, the liquid formed will, no doubt, show an acid reaction.

As to standard practice in fluxing for hot-dip tinning of cream cans, also retinning them, I might say that greases and tallows are used for two purposes, namely, to stop oxidation and forming of tin yellow, and for stripping purposes so that too heavy a tin deposit is not made as coating.

In ordinary tinning of work that is to be re-coated, the finish, of course, cannot be expected to have the quality and finish of a new tin coating. In many cases, therefore, this kind of tinning is done with a flux of zinc chloride to which some white fine sal ammoniac has been added. This kind of flux is generally considered sufficient for this type of work. (Retinning).

Then there is the higher temperature tinning at about 570-620° F., in which the articles are dipped in a liquid solution of zinc chloride and white fines (white fine powdered sal ammoniac) is thrown on the bath surface to keep down oxidation. It may be that the material the company uses is a mixture of this white fine sal ammoniac mentioned and zinc ammonium chloride. Such a mixture could be used as a flux, and would be placed in condition by simply adding water; of course, it would be acid in character.

Still another method is the combination of the two—both sal ammoniac flux and grease flux. A very large company doing that kind of work first dips the articles in a solution of zinc chloride. Next it passes over to a rough tin bath on top of which is a zinc ammonium chloride slag flux that is conditioned with new coarse gray sal ammoniac from time to time. Coming from this rough tin bath, the articles then go through a rough grease pot bath and then into a finishing tin bath and then into a finishing grease bath. They are then listed and the coating is set in an oil bath.

Technical Advisors For August Issue

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Then there is grease retinning in which such articles as are made of tin plate are retinned. This class of work is dipped in the finishing tin bath, then in the finishing grease pot and handled in the usual manner. New articles and work that have also been rough tinned are prepared for tinning by soaking in the rough grease pot, or as it is called, the "soaking" grease pot. Articles that are rusted are often taken completely apart and pickled in hydrochloric acid before retinning.

If you will keep in mind the distinct use and function of a flux, it becomes clear that certain operations and materials must be used regardless of trade secrets. The fluxes are zinc chloride, zinc ammonium chloride, white fine sal ammoniac, and ordinary coarse gray sal ammoniac. These are used as both a liquid flux dip and as a slag flux on the rough tin pot bath. The greases are used for two purposes—first, preparing of the work (most grease contains a very small percentage of fatty acid, and hence treatment in the soaking grease also tends to pickle gently too), and second, to keep down, or stop oxidation of the tin coating and strip down the excess tin. Only the very highest quality prime tallow should be used in the grease pots, and the tallow for the soak pot should always be dipped from the finishing grease pot. The new tallow should always be added to the finishing grease pot.—W. G. Imhoff.

Faulty Silver Solution

Q. By express we are sending you a sample of our silver plating solution. I wish you would tell us what is wrong with it, if this is not too much to ask. Lately, the objects we have plated turn brown in spots, blisters form, and adhesion is quite poor.

Incidentally, most of our silver plating is refinishing rather than new work. It might be possible that we are not getting these articles as clean as we should before plating, and I wonder if you would suggest a good cleaning method or formula with which we could do a good job of silver plating on pewter and nickel. The stuff we really had trouble on was pewter hollow ware with nickel silver handles. It may be possible that we are not handling this in the correct way. Please give us details and instructions on how to replate these articles.

A. The solution has been tested and shows the following:

Silver	1.70 tr. oz./gal.
Free sodium cyanide	0.90 oz./gal.

The free cyanide is low. It can be brought up to between 2 and 3 oz./gal. for best results.

The silver content can be left as is, but if moderate or heavy deposits are desired, the silver content should be at least 2, and preferably 2½ or 3 oz./gal.

To bring your silver content to 2 oz./gal., an addition of 0.41 oz./gal. of silver cyanide is required. The amount of sodium cyanide required to take 0.41 oz. of silver cyanide in to solution is 0.15 oz.

Poor adherence of the deposit can be due to several factors, such as overcleaning and causing a smut to be formed on the work. It is better, as a general cleaning procedure on soft metal work, to have the work as clean as possible before going in to an alkaline cleaner, so as to keep the time in the alkaline cleaner at a minimum, and thus reduce the attack on the metal. Precleaning can be done by fanning off on a clean rag wheel, or by solvent degreasing.

It is also desirable, after alkaline cleaning, to wet scratch brush the work.

The brown color of the deposit can be due to metallic impurities in the solution. The removal of impurities of this nature is not practical. It is better to recover the silver from the old solution, and then make up a new tank with new chemicals.

We note you do not refer to any "strike" operation. It is not possible to plate work directly in a silver plating solution without obtaining a deposit of silver on the work by immersion, which deposit is non-adherent and will cause peeling of the subsequently applied deposit. For details refer to the silver plating section of the 1941 Plating & Finishing Guidebook.—G. B. H., Jr.

Brush Plating Apparatus

U. S. Pat. 2,244,620. W. A. Hesse, June 3, 1941. A brush electroplating apparatus of novel design containing an anode surrounded by a removable envelope which will hold the plating solution, a handle and connections.

ELECTROPLATING DIGEST

SELECTED ABSTRACTS ON PLATING—FINISHING—RUST PROOFING—LACQUERING

Corrosion Prevention in Cooling or Heating Systems

U. S. Patent 2,208,101 J. M. Michel, assignor by mesne assignments to Walther H. Dusiberg. A method of preventing corrosion in heat interchange systems, which method comprises establishing in the water a solution of an alkali metal monochromate and an alkali metal dichromate in such proportion that the aqueous solution has a pH value lying between about 5 and about 7, the concentration of chromate being at least about 1% of the total water content of the system.

Example:

Alkali metal monochromate	22 parts by wt.
Alkali metal dichromate	78 " " "

Use 1% of the above mixture in the water supply.

Plating Machine

U. S. Patent 2,244,423. W. F. Hall, assignor to Hanson-Van Winkle-Munning Co., June 3, 1941. A machine for electroprocessing long continuous substantially flat strips of metal.

Hot Tinning Machine

U. S. Patent 2,244,388. D. H. Davies, assignor to Richard Thomas & Co., Ltd. (England), June 3, 1941. An apparatus for hot tinning sheet metal.

Plating Barrel

U. S. Patent 2,243,728. J. V. Davis, assignor by mesne assignments, to The Udylite Corp., May 27, 1941. A plating machine of improved and novel design for bulk work.

Electroforming

U. S. Patent 2,243,521. J. W. Bishop, assignor by mesne assignments, to United States Rubber Co., May 27, 1941. A method of forming tire mold sections by depositing on a rubber model.

Buffing Wheel

U. S. Patent 2,240,559. P. E. Hawkinson, assignor to Paul E. Hawkinson Co., May 6, 1941. A buffing wheel made up of hingedly connected segments.

Degreaser

U. S. Patent 2,240,989. N. R. Hood and S. B. Spencer, assignors to Imperial Chemical Industries Ltd. (England), May 6, 1941. A degreasing machine for metal sheets comprising a compartment for a volatile solvent, a heating element, a cooling element and a rotating carrier for the sheets.

Vitreous Enamel

U. S. Patent 2,241,520. V. H. Remington and R. Andrews, assignors to B. F. Drakenfeld & Co., Inc., May 13, 1941. A vitreous enamel containing approximately 63% lead oxide, 31%-33% silica, 3%-4% boric oxide and approximately 1.5% sodium oxide.

Bright Nickel

U. S. Patent 2,238,861. R. Lind, W. J. Harshaw and K. E. Long, assignors to Harshaw Chemical Co., April 15, 1941. Bright and ductile nickel deposits are claimed by using addition agents, one of which consists of one or more aromatic amino compounds soluble in the bath to the extent of at least 0.002 g./l. and characterized by a brightening tendency at a concentration between 0.002 and 0.10 g./l., the other of said addition agents consisting of one or more sulfur containing aromatic compounds soluble in the bath to the extent of at least 0.2 g./l., selected from the group consisting of the naphthalene mono-, di-, and tri-sulfonates, benzene sulfonamides, toluene sulfonamides, orthobenzoic sulfimides (saccharin, soluble saccharin) and sulfo-hydroxamic acid and characterized by a ductilizing tendency, said first mentioned addition agent being maintained in solution in concentrations above 0.2 g./l. 23 Examples are given in the patent.

Example:

Nickel sulfate	240 g./l.
Nickel chloride	37.5 "
Boric acid	37.5 "
Quinine bisulfate	0.010 "
Paratoluene sulfonamide	1.6 "
Sodium lauryl sulfate	0.25 "
pH	4.0
Temperature	55° C.
C. D.	34 amp./sq. ft.

Detergent

U. S. Patent 2,239,974. C. F. Reed, assignor of one-half to C. L. Horn, April 29, 1941. A detergent composition consisting essentially of 35%-90% by weight of a water soluble alkali metal salt of a mineral acid and the balance a surface active product prepared by reacting a saturated aliphatic hydrocarbon in a liquid state at a temperature between 30° and 100° C. with a gaseous mixture of sulfur dioxide and chlorine and hydrolyzing the resulting product with an alkali metal hydroxide solution.

Chromium Plating

U. S. Pat. 2,234,189. J. J. Murray, March 11, 1941. A process of making zinc plates which consists of immersion in monochloracetic acid and then chromium plating the backs of the plates with chromium from a solution containing about 1½ lb. of chromic acid, 12 oz. of glycerine, 2 oz. of phenol, 3 oz. of ammonium persulfate and 1 gallon of water at 140° and 390 amperes/ft².

The chloracetic acid dip contains about 8 oz./gal. and is operated at about 100° F. with about a 3 minute immersion.

Another recommended solution contains approximately:

Chromic acid	2½ lb.
Glycerine	8 oz.
Phenol	2 "
Ammonium persulfate	3 "
Water	1 gal.

Phonograph Records

U. S. Pat. 2,240,300. J. H. Hunter, assignor to Radio Corporation of America, April 29, 1941. A method of improving the adherence of the metallizing powder to the wax recording comprising the incorporation in the powder of about 0.1% by weight of a fatty acid such as stearic acid, oleic acid, etc. This is claimed to eliminate trouble with lack of adherence in cold weather.

Detinning Steel Plate

U. S. Pat. 2,243,165. M. Mandl, assignor to The Standard Metal Refining Co., May 27, 1941. The efficiency of the detinning process is improved by detinning in a caustic solution containing from 7-10% of free caustic alkali and 1½% collectively of a cobalt oxide, an alkali metal aluminate, dextrine and starch in the ratio of 4:2:2:1. Operated at 60-80° C. and 70 amperes per square meter, the metal collects as a cathode mud.

Plating Non Conductors

U. S. Pat. 2,243,429. R. Laux, assignor to Langbein-Pfanhauser-Werke, A. G. (Germany), May 27, 1941. A process comprising production of a thin film of metal on a non-conducting surface by reduction, immersion as cathode in a solution of copper sulfate and free sulfuric acid having a pH of 3.4-1.8 to deposit some copper and then building up in a concentrated copper plating solution.

Ex: *First Bath:*

Copper sulfate	40-100 g./l.
Free sulfuric acid	approx. 2.5 g./l.
pH	3.4-1.8

This does not attack the conducting film even if the current is off for several hours.

Ex: *Build-up Bath:*

Copper sulfate	200-300 g./l.
Sulfuric acid (free)	15-40 "
pH	1.1-0.9 approx.

Fundamentals of Science Relating to Electroplating

Chapter XI. Introduction to Electrochemistry

The modern electroplating industry is a curious concoction of old and new: old plating formulae that started the industry over a hundred years ago and which are used practically unchanged now, new speeds of plating that are to the old rates as the hare is to the tortoise. However, and this is as it should be, the discovery that led to the birth of the industry 150 years ago has certainly grown and progressed with the years—the little cell of Galvani and the Pile of Volta, which have grown to be our mammoth generators and our newer rectifiers.

Electrochemistry, on which our electroplating industry is built, is defined as the science that deals with chemical changes produced through the medium of electricity, and the production of electricity as a result of chemical reaction. The electroplater is concerned mainly with the former, but the latter half of the science has been responsible for the creation of the industry and it is with that, therefore, that we start.

It all began when Professor Galvani of Bologna, in 1789, suspended some frogs from metal hooks, with their legs touching his iron fence. He noticed that the muscles twitched involuntarily and soon found that he could produce this twitching at will by touching the frogs with dissimilar metals which at the same time either touched each other or were connected through certain conductors. It was naturally thought at first that the frog was the source of this electricity, and it was not until a contemporary scientist, Professor Volta, studied this "animal electricity" in detail that the discovery was made that only two dissimilar metals were necessary to obtain "striking results." This led to the first deliberate scientific source of dynamic electricity, the Pile of Volta, which consisted of a plate of zinc, a plate of silver, a moist felt pad, then a plate of zinc again and the whole sequence repeated many times.

The Voltaic Pile made possible the real birth of electrochemistry by Sir Humphrey Davy in London in 1800, when quite accidentally he discovered that water could be decomposed by electricity. In 1807, he staged a scientific show of which the mighty Barnum himself would have been proud. There he electrodeposited sodium in mercury, not from aqueous solution, but from "igneous fusion", which really amounted to a miniature arc furnace. The mercury was stiffened due to amalgamation with sodium and this he dropped into water, forming thus caustic soda in solution and hydrogen gas, which he lighted, to the amazement of his audience. This proved the original presence of the sodium—and the march of electrochemistry and electroplating had begun.

In 1836 Daniell developed the chemical battery represented by the type which now bears his name. This was a much better source of electricity than the Voltaic Pile and made possible the first real electroplating, as we now know it, by Elkington in 1836 and later (in 1839) by Jacobi with his electroreproduction. In 1840, Wright began the development of plating solutions, so sound in foundation as to hold true to a great extent even today, as has already been said. It was he who in 1849 started cadmium plating, only to have it remain practically untouched until some twenty years ago.

Meanwhile, in 1834, the theoretical basis for electroplating had been laid by Davy's assistant, Michael Faraday. Considerable was already known by that time. It was realized that the decomposition of liquids was due to the motion of dynamic and not static electricity, that salt solutions or acid solutions acted more quickly, that reactions took place at each immersed metal surface and that often gases were liberated. Faraday took these qualitative concepts and began to build a science round them. First he named the various processes, components and phenomena from Greek expressions. He used the word electrode to denote the surfaces which bounded the electrochemical reaction, that is, which acted as the outside limits between which the reactions took place. The anode became that surface, according to our present conception of it, which is positively charged. The cathode became that surface which is negatively charged. It has been shown in a previous chapter that any electrically conducting solution contains ions, or atoms charged either positively or negatively, and that it is these moving charges of electricity that constitute the passage of current through a cell. When a potential difference (a voltage) is applied, that is, when the electrodes are charged, one positively and the other negatively, those ions which have negative charges are attracted to the anode (positive electrode). Those ions which are positively charged (all the metal ions, hydrogen and the ammonium radical) are attracted to the cathode (negative electrode). Said Faraday about such moving "bodies": "I propose to distinguish such bodies by calling those anions which go to the anode—and those passing to the cathode, cations; and when I have occasion to speak of these together, I shall call them ions." (Ion in Greek means "going".) Thus the cathode serves to bring into the solution electrons (the negatively charged units of electricity) to neutralize the positive charges of the cations, which are the metallic ions. For example, the nickel ion is Ni^{++}. On reaching the cathode, two electrons are taken up to neutralize the two positive charges. This "reaction" may be shown as follows:

$$Ni^{++} + 2\,\theta = Ni$$

The θ indicates an electron. Ni indicates neutral nickel, that is, electrodeposited nickel.

At the anode, the anions release their electrons. Thus in the case of a chloride solution, containing the negative ions or anions of chlorine (Cl^-) the following happens:

$$2\,Cl^- = 2\,Cl + 2\,\theta$$

The 2 θ are neutralized by the positive charge on the anode and the neutral 2 Cl eventually pass off as chlorine gas. The anode is thus the electrode at which the electrons, separated from the anions, leave the cell.

In the above sense, the motion (migration) of ions through the solution and the neutralization of some of them at each electrode constitutes the passage of the electric current. The current is *produced in* the solution and does not consist of an *external* current passing *through* the solution. The external generator, rectifier or battery only furnish the electrical energy to charge the electrodes either positively or negatively.

Continued Faraday: "Many bodies are decomposed directly by the electrical current, their elements being set free; these I propose to call *electrolytes*. . . . Then for *electrochemically decomposed* I shall often use the term *electrolyzed*," i.e. electrolysis becomes the decomposition of chemical substances by electricity. By definition therefore only electrolytes can be decomposed by the current, and this decomposition comes about in this way: the electrolyte, when dissolved in water, ionizes, as described in a previous chapter; the ions formed are neutralized at the proper electrode after being caused to move there by the application of the voltage, as described above; the neutral substances are released, for example as a deposited metal or as a gas. Note again, as stated above in different words, that the charges exist on the ions before the voltage is applied, that is, ionization eventually may *result* in the passage of current but it is not *caused* by it.

Acids, bases and salts are therefore electrolytes. They may be simple electrolytes like sodium chloride, NaCl; they may be complex like ammonium chloride NH_4Cl; or they may be, for example, polybasic, like potassium ferrocyanide $K_4Fe(CN)_6$. Gradually the word "electrolyte" has come to be used to mean also the *solution* containing the dissolved substances and though attempts have been made to establish different words for these two items, the one word is still widely used for both meanings.

So far, then, we have arrived at these definitions and conclusions: An electrolyte is a substance which yields ions when dissolved (in

water, as far as we are concerned) thereby producing an electrically conducting solution. The passage of electricity through this solution is accomplished by the actual migration of matter from one place to another (thus differing from metallic conductors) and is accompanied by chemical changes at the electrodes. It should be noted that the ions which carry the current through the solution are not necessarily the ones that react at the electrode. For example, if sodium chloride is added to a poorly conducting nickel plating solution, the conductivity of the solution is increased because there are more ions (sodium and chlorine ions) present to carry the current. However, the sodium does not undergo any reaction at the cathode. Nickel is still the only ion (except hydrogen) that reacts there. Therefore, while the addition of sodium chloride improves the electrical *conductivity* of the solution, it has no direct effect on the efficiency of plating nickel, as might at first seem inevitable.

Conduction, Conductivity, and Conductance

The title words—conduction, conductivity and conductance—are very commonly misused, especially by the electroplater. Their use here is restricted to the electrical field, of course, and does not refer at any time, unless so stated, to heat. Conduction refers to the general process or act of passage of electricity through a conductor, whether it be the passage of electricity through a wire or through a solution or through a gas. Conductivity (and here specific conductivity will always be meant) refers to the property of the conductor as a material which makes it relatively easy or difficult for the electricity to pass. It has nothing to do with size or shape, only with the material itself. When size or shape enter the picture, so that one is concerned with the passage of electricity through a whole unit such as a plating tank containing solution, then conductance is the word to be used. Thus the conductivity of a copper solution is the same whether it is in a 2 gallon crock or in 1000 gallon tank, because the material is the same and in the same condition. The conductance (which is the reciprocal of resistance) is quite different in each case, because the dimensions involved are quite different.

It was stated in a previous chapter that resistance increased as the length of the conductor increased and as its area decreased. With conductance the opposite is true. This may be expressed mathematically as follows:

$$\frac{\text{Conductance a}}{\text{Conductance b}} = \frac{A_a L_b}{A_b L_a}$$

Where A_a is the cross-sectional area (assumed uniform) of the conductor a

A_b is the cross-sectional area (assumed uniform) of the conductor b

L_a is the length of conductor a

L_b is the length of conductor b

Let us apply this to a rubber lined plating tank with the dimensions shown in Figure 12.

The conductor in this case will be a copper solution which fills the tank to the brim. If the electrodes are placed to cover the sides "a", we have the current flowing from one side to the other side and shall call this conductor "a". If the electrodes are placed to cover the ends "b", the current will flow from one end of the tank to the other end and we shall call this case conductor "b".

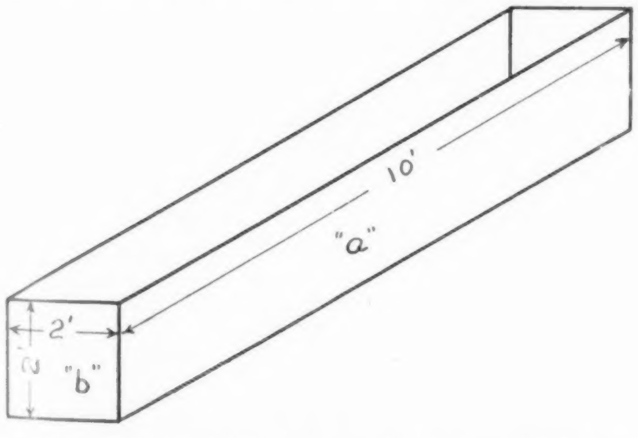


Fig. 12. **Drawing of a rubber lined tank with dimensions to illustrate determination of conductivity as discussed in the text.**

A_a (area of side "a") = 2 x 10 = 20 sq. ft.
A_b (area of end "b") = 2 x 2 = 4 sq. ft.
L_a (distance between sides) = 2 ft.
L_b (distance between ends) = 10 ft.

$$\frac{\text{Conductance a (between sides)}}{\text{Conductance b (between ends)}} = \frac{20 \times 10}{4 \times 2} = 25$$

In other words, the conductance between the sides is 25 times as great as that between the ends and only one-twenty-fifth of the voltage which is required to drive a given current from end to end would be required to drive it from side to side. In either case, however, although the conductance is different, the conductivity is the same, because it is the same solution in the same condition.

How can the conductivity itself be varied? This can be done, practically speaking, by changing the chemical nature of the solution, by changing the concentration of the ingredients in the solution, or by changing the temperature. Other factors including viscosity, the presence of non-electrolytes, the nature of the solvent, and other variables, also exist but are of such limited practical importance that they will not be considered here. The important variables, however, will now be discussed.

It has been stated that the passage of current through a solution is due to the ionization of the dissolved electrolyte and the movement or migration to each electrode of the ions so formed, that is, of the charged particles. Now there is no reason for assuming that different types of ions all move in the same manner and with the same speed through the solution. As a matter of fact, the various ions have different speeds. Hydrogen moves the fastest of all. The hydroxyl ion (OH^-) comes next, at about 60 per cent of the speed of hydrogen. Then the other common ions drop to about a third of the hydroxyl, etc. In a copper plating solution, for example, the hydrogen migrates about 7.5 times as fast as the copper to the cathode and about 4.5 times as fast as the sulfate moves to the anode These, of course, are only relative speeds. The actual speed can also be measured, or computed. The actual speed of the swiftest of all, the hydrogen ion, is less than two inches per hour at room temperature, at a voltage gradient of 1 volt per inch. With the metal ions moving at much less than this speed, it is obvious that were it not for mechanical agitation and diffusion, the supply of metal produced at the anode would be a long time in reaching the cathode, with consequent depletion of the metal there, where it is most needed.

Because of the different speeds with which the ions move through the solution, the different ions carry different percentages of the current. When a solution of caustic soda (sodium hydroxide $NaOH$) is electrolyzed, 17.5 per cent of the current is carried by the sodium ion (Na^+) and 82.5 per cent by the hydroxyl ion (OH^-), because the latter moves so much faster than the former. This percentage, expressed as a decimal (e.g. 0.175 & 0.825) is called the "transference or transport number" of that ion under those conditions. In an acid nickel solution, to give a further example, since the hydrogen and the sulfate and other ions move faster than the nickel ions, a relatively small number of nickel ions are *electrically* transported to the cathode, that is, the number of nickel ions moving to the cathode corresponds to a small percentage of the current. Since the nickel actually deposited corresponds to almost all of the current, it is again evident that the solution near the cathode would be rapidly lowered in nickel concentration if diffusion and agitation did not remedy the situation. Furthermore, if the situation were not remedied in this fashion, it would not be long before only hydrogen and poor nickel deposits were obtained—but more about this later.

The migration and transport numbers of ions have been discussed here to show how the chemical composition of a solution can affect the ease of conduction of electricity through that solution, that is, its conductivity. It has already been mentioned that the addition of other salts to a solution will increase the conductivity merely by introducing more ions to act as electricity carriers. There is actually a limit to which this increase in conductivity can be carried out, due to the entrance of other electrical and chemical factors into the picture, and beyond this limit the specific conductivity actually decreases. This limiting concentration is, however, usually much higher than any used in practical electroplating and need not concern us here. It should be pointed out, however, that the higher the conductivity of a solution, the less effect will a further addition of chemicals have, by the same token

that a job being done by five men will be greatly accelerated by the addition of five more men, but when the number of workers on that same job reaches 100, then the addition of five more men, or even two and three times that number, has relatively little effect.

Finally, there remains the question of temperature as affecting conductivity. This relation is fairly simple since the specific conductivity of an electrolyte increases almost directly with the temperature, at least for temperatures up to the boiling point of commercial plating solutions. An approximate figure often used in this connection is an increase in conductivity of about 1 per cent per degree Fahrenheit increase in temperature.

Summary

Electrochemistry, as far as platers are concerned, deals with the chemical changes produced as a result of the passage of electricity through a solution. The passage, or conduction, of the electricity through the solution is due to the migration of ions in the solution under the influence of an electromotive force or voltage. The positive, metallic ions, called cations, are attracted to the negative electrode called the cathode; the negative, non-metallic ions, called anions, migrate to the positive electrode, the anode. The chemical substance which ionizes, when dissolved, to furnish the above ions is called an electrolyte, although this name is often applied also to the solution itself. The process of electrochemically decomposing an electrolyte, for example, to form a metal from a salt, is called electrolysis. Electroplating is electrolysis. The conductivity of a solution refers to the ease with which current passes through a unit cube of it and depends upon the chemical nature of the electrolyte, the concentration of the dissolved substances, the temperature of the solution, and on other less important details. The conductance of a solution refers to the ease with which the current flows through the solution when it is contained in a tank of definite dimensions with definite electrodes, that is when the size and shape of the path along which the electricity flows must be considered. The conductivity of a solution may be increased by the proper choice of electrolytes, by increasing the concentration of these electrolytes, and by raising the temperature. The conductance can be increased by increasing the conductivity of the solution, by increasing the cross-sectional area of the path, and by decreasing the length of the path. The greater the conductance, the smaller is the voltage that must be applied, in accordance with Ohm's law as stated above. Because of the slow speeds with which metal ions migrate, diffusion and usually agitation are necessary for satisfactory electrodeposition.

Coloring Stainless Steel

U. S. Pat. 2,243,787. C. Batcheller, assignor to Allegheny Ludlum Steel Corp., May 27, 1941. A method of forming a design on a stainless steel surface which comprises subjection to a solution of about 35-64 parts water, 23-54 parts sulfuric acid and 4-25 parts of an etching inhibitor, which is preferably a chromate or dichromate, at a temperature of from about 185° F. to about 200° F. for a time sufficient to color same, masking certain parts, removing the color from the exposed parts and then coloring the exposed parts a gold color in a solution containing:

Ammonium metavanadate	4-30 parts
Sulfuric acid	20-60 "
Water	35-70 "

It's Patented

Numerous patents issued in the past and especially in the last few years, covering electroplating processes, alloy plating and bright plating must necessarily have a very doubtful value since practically all of the methods mentioned in the claims have been referred to time and again in the literature covering such subjects, many years before the respective patent applications, while others are so broad or general that almost anything you may do with a plating bath seems to interfere with one or more of about five dozen patent claims.

The same condition exists with casting alloys, finishing processes, such as bright stripping, heat treatments, chemical dips, etc. Previous to U. S. Patent No. 1,777,121, at least fifteen years ago, the following addition agents were mentioned in articles and books on plating in connection with silver, nickel, copper, brass, chromium and zinc: The halogens, iodine, fluorine, chlorine and bromine; the metals, cobalt, aluminum, iron, cadmium, tungsten, caesium, tantalum, molybdenum, magnesium, thorium, antimony, cerium, vanadium, manganese, lead, tin and arsenic; the organics, phenols, naphthas, benzenes, cresols, toluol, sugars, gelatin, dextrin, glue, proteins, citrates, tartrates, essential oils, glycols, acetates, ethers, ketones, ethanol, methanol, salycilates, ureas, picrates, lactates, laurates, aniline, tannin, oxalates, gums, resins and such substances as triamyl borate, glyceryl triacetate, carbon disulphide, caffein, nicotine, morphine, dimethylglyoxime, sulphocyanates, chalk, plaster, clays, carbon, peat-moss, lignin-sulphonic acid, etc.; the metallo-organics, ferrous chrome oxalate, chrome acetate, copper acetate, lead acetate, ammonium-phenyl-molybdate, zinc-methyl-aldehyde, manganese-acetyl-borate, potassium ferrocyanide, titanium-potassium oxalate and argento-urea.

All of the above substances have been mentioned as actually used and have been abandoned in general, perhaps because of the inability to maintain the few which were of benefit.

In general, the halogens or any elementary substances which combine directly have been known to have a noticeable effect in plating baths, almost all being unsuitable for permanent effects.

Metals and metallo-organics have far-reaching effects, but unless checked and properly maintained, a desirable effect may slough off suddenly, sometimes completely upsetting the characteristics of the bath requiring immediate changes in current density, temperature, concentrations or pH. Organic compounds affect solutions containing those well known trouble sources: sodium, ammonium and compounds containing these two with carbon, specifically carbonates.

Considered new, but mentioned in the above cited patent 1,777,121, is the use of gases. This particular process refers principally to hydrogen but other gases are mentioned among them—two so-called inert gases, argon and radon. It has been found lately that with these gases in the presence of certain organics such as phenols, sugars and ureas, there is a noticeable difference in the effect of electrolysis of solutions containing metals. Chemical reactivity of any kind in the inert gases has important implications for the theory of inert substances and should shortly be the basis for research in an entirely new field.

New also, but probably too late for patent application, are two methods for checking the appearance of an active electrolyte. A photoelectric cell (W. E. Standard Caesium Oxide Cell) with an exciter or pilot lamp as a standard light source are placed eight inches apart, eight inches below the surface of the bath under test, at right angles to and halfway between anode and cathode, which are also eight inches apart.

Changes are noted with high resistance ear-phones, covering both ears and are recorded on a moving paper tape, similar to a cardiograph in action.

Another system employs a moving picture camera with lens in place of the photo cell, sharply focused at the smallest possible aperture, to a distance of four inches. The pilot lamp is diffused in this case by use of a frosted glass.

The writer recommends an article on the patent situation by Thurman Arnold, U. S. attorney general, appearing on page 51 in the July 1941 issue of Reader's Digest.

Here is something that really belongs on Dr. Walter Meyer's page. It refers to some of the phraseology used in patents: No. 2,239,864 issued April 29, 1941 covers: "—an ethynyl derivative of cyclopentanopolyhydrophenanthrenes, keto-substituted in the 17-position, which comprises reacting the appropriate phenanthrene derivative with acetylene in presence of an alkali metal alcoholate." (Hot dog!)

Leslie L. Linick

NEW EQUIPMENT AND SUPPLIES

NEW PROCESSES, MATERIALS AND EQUIPMENT FOR THE METAL INDUSTRY

New Barrel Plating Unit

The Udylite Corporation, Detroit, Michigan, manufacturers of plating equipment and supplies, has introduced a new barrel plating machine known as the "Multi-Purpose" barrel. It may be used for a variety of purposes such as cleaning, drying, plating, rinsing or pickling.

The Multi-Purpose Barrel is rugged and efficiently designed. There are no bearings below the solution level. Removal of cathode contacts for cleaning is a simple, quick operation. The cylinder is roomy permitting large loads.

For cyanide plating (cadmium, zinc, etc.) or electrocleaning, plain steel tank with anode rods and terminals are used; steel steam coil if necessary; steel, rubber covered cylinder with cathode contacts. For acid plating (nickel, etc.) steel, rubber lined tank with anode rods and terminals are used; lead steam coil if necessary; rubber covered plating cylinder with cathode contacts. Tumble cleaning—plain steel tank; steel cylinder; steel steam coil. Pickling—steel rubber lined tank; monel cylinder. Drying—plain steel tank equipped with unit heater; steel cylinder. Rinsing—plain or rubber lined steel tank; plain or rubber covered steel or monel cylinder; steel or lead coil if necessary.

Specifications—tank 32 x 36 x 30 inches—3/16" steel welded inside and out—125 gallon capacity. Cylinder—23" x 23" with 16" opening. Built-in loading chute. No bearings under solution. Contacts easily removed and cleaned. Capacity—50 to 70 lbs., about one peck. Perforations—3/16" standard—larger if desired. Motor—1/6 HP 110 volt, single phase, 60 cycle, AC, cord and plug included.

Plating barrel in unloading position. The unit is unloaded by means of downward pressure exerted on the handle and foot pedal at right.

Plating barrel in operating position

New Anode Scrap Baskets

A new type of basket for handling scrap anodes has been developed by the Hanson-Van Winkle-Munning Co., Matawan, N. J., manufacturers of electroplating equipment and supplies. Because of the present shortage of metals, the efficient use of scrap is of vital importance to the electroplating plant.

The H-VW-M rubber covered scrap anode basket is furnished with two hooks, allowing the basket to be hung on anode rods in still tanks and plating barrel tanks. A new anode is inserted in the basket and hung on the anode bar. The anode stubs are placed in the basket around the new anode allowing this metal to be used.

The basket is made of steel wire with proper reinforcements at the top, at all ends and at the bottom. The steel mesh used is welded to the frame and the entire basket is rubber covered. The unit is rugged in construction and neat in appearance.

The baskets can be used in solutions where temperature does not exceed 180 to 190° F. (Almost all plating solutions are operated below this temperature.)

Anode scrap basket

The hook for the scrap anode baskets can be furnished 4″ or 5″ long as desired, and the baskets can be made to dimensions specified. The following are considered standard sizes:

9″ long	x 18″	deep x 4″	wide
12″ "	x 24″	" x 4″	"
16″ "	x 30″	" x 4″	"
20″ "	x 40″	" x 4″	"

The above dimensions are inside measurements, the outside width being approximately 1″ additional.

The Hanson-Van Winkle-Munning Company is also in a position to furnish anode bags for these baskets.

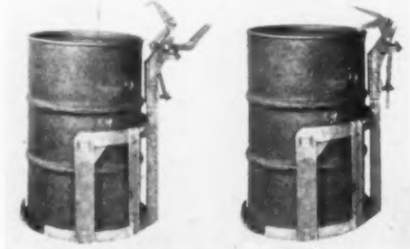
Toggle Type Barrel Dumping Harness

Lewis-Shepard Sales Corp. 245 Walnut St., Watertown, Mass., present a new, quick-locking harness for handling and dumping of barrels and drums.

Now it is possible to place a drum in the harness direct. No longer does the harness have to be affixed to the drum or adjusted to it. A standard type of Lewis-Shepard barrel hoop truck deposits the drum directly into the harness. Thus the drum does not have to be placed on the floor first as formerly and one complete operation is eliminated.

The harness is equipped with a spring toggle, is arc-welded throughout, and can be made for any size of drum.

Used in conjunction with the Lewis-Shepard Master Dumping Stacker No. 7410 and the Lewis-Shepard Barrel and Hoop Truck, it provides a new three-way modern drum handling and dumping system.



Toggle type barrel dumping harness.

New Rectifier and Voltage Regulator

In announcing its new 500-ampere fan-cooled copper oxide rectifier for electroplating service, and a separate "on load" voltage regulator, the General Electric appliance and merchandise department, Bridgeport, Conn., points out that "on load" control permits adjustment during operation without interrupting the current flow in the plating tank. This is particularly helpful in plating bright nickel and certain other materials. Several sizes are available so that a number of parallel rectifier units can be controlled simultaneously from one regulator. The new rectifier and regulator are advantageous in plating rooms where expansion is taking place, or where frequent changes in the type of work may require changes in voltage amperage requirements. The rectifier units can be readily moved about and reconnected in various parallel arrangements to meet new conditions.

The rectifiers can be mounted anywhere singly or in groups, and the separate "on load" regulator gives the operator complete control at the tank. The new rectifier, like the G-E 300-ampere rectifier for electroplating, is an adaptation of the G-E fan-cooled copper oxide rectifier which has been used so successfully in motion picture service and in various industrial applications. In applying this rectifier to electroplating, separate units can be used for each electroplating tank, instead of large units serving several tanks as is customary with rotary equipment.

With this arrangement, approximately full-load efficiency can be maintained at all times because the rectifiers can be shut down on any tanks which are not being used. The overall full-load efficiency is about 70 per cent. This efficiency is maintained down to

New 500-ampere rectifier.

about half-load and falls off only slightly at 25 per cent load. A power factor of 90 per cent or better will be obtained over the normal operating range.

Two maximum direct-current voltage ratings are available, in 6 and 12 volts. Standard units are designed for operation on 230 volts, 3 phase, 60 cycles, or on 440 volts, 3 phase, 60 cycles. Adjustments are provided to compensate for wide fluctuation of these line voltages. The hand-operated "on load" voltage regulator provides a simple and convenient means for adjusting the voltage output of the rectifier.

New Alkaline Copper Plating Process

United Chromium, Inc., 51 E. 42nd St., New York, have developed a new alkaline copper plating process. The plating bath is a mildly alkaline bivalent copper solution operated at an electrometric pH of about 8.5. The throwing power is stated to be excellent and no brighteners, wetting agents or special addition agents are required.

The bath contains no cyanide and ventilation is unnecessary. The chemicals used are specially prepared salts which are readily available, and the cost of the bath at prevailing prices is approximately 80¢ per gallon.

The operating temperature is from 100 to 140° F., current densities from 20 to 40 amperes per sq. ft. Cathode as well as anode current efficiencies are 100% and the bath constituents are reported to be stable and easy to control. The exceptional smoothness of this copper, according to the manufacturer, makes it an excellent base for bright nickel, and where buffing is required, results in easy flow, minimum wheel wear and low labor cost.

A simple licensing arrangement has been worked out based on the copper anode consumption of the bath.

Further details are given in a bulletin supplied by the company.

Belt Surfacer

A new bench-type belt surfacer for wet or dry buffing, burring, surfacing or polishing is now being manufactured by Hammond Machinery Builders, Inc., 1601 Douglas Avenue, Kalamazoo, Michigan.

The surfacer is designed to reduce the number of rejects in lots of cast or moulded pieces, and to facilitate finishing work formerly done by hand. Versatility in the type and number of different materials successfully finished is an outstanding feature claimed for the machine. Plastics, stainless steel, ceramics, hard rubber, stone, lead, aluminum, wood and many other types of materials may be finished with it. With the proper abrasive belt, the machine may be used for rough work such as removing sprues and flash from rough castings. With a different type belt, a fine luster may be developed on glass, pottery, plastics and like materials.

Belt surfacer.

Simply, but sturdily built, all parts of the surfacer conform to machine tool specifications. Base of the machine is heavy cast iron. Belts, of which a wide variety may be used, are 4" x 35" endless type, running over 4" drive and idler pulleys with 4½" face. Each pulley is dynamically balanced and turns over dust-proof ball bearings. The belt is adjusted to proper position on the pulleys by means of two opposing thumb screws.

For positioning work against the belt, a work rest, easily adjustable on a segment, is mounted on the frame slightly forward of the drive pulley and projecting over the belt.

Power is furnished either by direct or V-belt drive from a ⅓ HP motor operating at 1725 RPM.

The Hammond "400" operates in any position between horizontal and vertical, pivoting on center of the drive pulley and locking into position by means of a positive clamp on the base of the machine.

For wet surfacing operations, a sheet metal casing is fitted around the machine. Coolant is piped to the belt by a tube inserted through the side of the hood, ending in a spray nozzle which distributes coolant fluid evenly across the belt.

Descriptive literature and prices for the Hammond "400" Belt Surfacer may be obtained from Hammond Machinery Builders by writing for Bulletin GP-2.

Refinement of Selenium

Another of the interesting sidelights of the National Defense Program is the fabulous increase in the refinement of pure selenium in the United States which, according to George Lewis, Vice President of International Telephone and Radio Manufacturing Corp., has increased one hundred fold this year over last.

Selenium is one of the lesser known of the physical elements but is employed in the manufacture of red glass, certain pharmaceutical products and now in the I.T.T. selenium rectifiers which are being used extensively by various National Defense suppliers. The application of selenium in rectifiers was developed by a subsidiary of the International Telephone and Telegraph Corporation in Europe and, Mr. Lewis says, that an impression has existed that selenium is a European material. The fact is, he points out, that practically all of the world's supply is obtained in the United States and Canada.

Rectifiers for Electroplating

The Benwood Linze Co., St. Louis, Mo., announces an addition to their established line of rectifiers and rectifier equipment—a new "B-L Dry Plate Rectifier for Plating."

Prior to the present National Emergency, dry plate rectifiers were infrequently applied to electroplating processes. However, the unusual demand and increased pressure on all industries occasioned by the Emergency, brought about the necessity of expanding present electroplating production.

They are said to be flexible and economical in operation. They will serve individual tanks; or a number of units may be grouped together in parallel to meet the demands for heavy current loads; or the units may be grouped in series for maximum high voltage requirements.

The rectifiers are assembled in cabinets, as complete units, less controls. They are compact and mobile. Models are available for 300 ampere and 500 ampere capacities, at 6 volts and 12 volts—operating from 230 volt and 440 volt, three phase, 60 cycle, A.C. service.

Control units are also available which provide a variation in voltage from the maximum for the unit down to zero volts.

New rectifier for electroplating.

punch on the time scale. The location of these holes determines the time of operation of the cam mechanism. Discs for new cycles or schedules of operation can be easily made.

The cams are individually adjustable and their setting does not require fine adjustment in order to get accurate results. Any sequence of operation can be obtained.

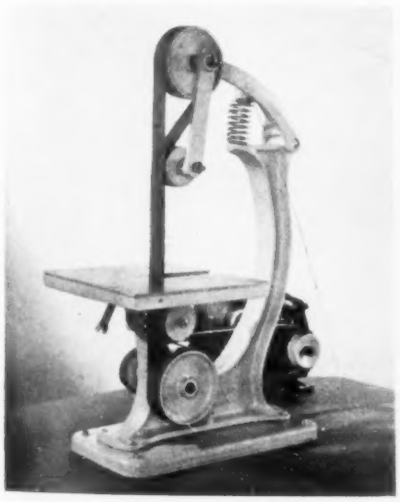
All controllers are drilled for eight cams and pilot valves. Additional cams and pilot valves up to a total of eight can be easily added by the user to controllers originally made up with less than eight cams.

A copy of Catalog 572 describing this controller may be obtained upon request.

Bandsander

Mead Specialties Co., 15 S. Market St., Chicago, Ill., have developed a new bandsander, which is stated to fill the gap between a band saw and final polishing operations.

It is capable of handling a variety of large sized objects. Forty-five inches of abrasive surface are available and pass the work at a rate of over 1600 feet per minute. Automatic cleaning of the bands is accomplished as the band flexes over the upper and lower wheels. The equipment is designed to operate at 1750 R.P.M., but



New bandsander.

by means of step pulleys, it can be run faster or slower. The work table tilts from a normal horizontal position to a 45° angle with the band, thus permitting a wide range of beveling on curved or straight edges.

The equipment is recommended for carving, shaping, polishing wood, plastic and metal objects. Literature is available describing and illustrating the construction and operation of the bandsander.

Electric Silver Solder Brazing Unit

A new electric brazer for brazing and soldering with silver solder is announced by the Ideal Commutator Dresser Co., 1919 Park Avenue, Sycamore, Illinois.

This brazer operates on the same principle as the company's Ideal "Thermo-Grip" soft soldering tools. It consists of a power unit or transformer and a pair of electric heating pliers. Holding the part to be brazed in the pliers, closes the secondary circuit causing the part to quickly heat to brazing temperature. Heat is accurately controlled by on-off foot switch.

Operator using new solder brazing unit.

The brazer is said to be compact, portable, easy to use and always ready in shop or field. When in use the cover turns back making a convenient shelf for flux, silver solder, etc. Compartments are provided for heating pliers, foot switch, silver solder and flux. When not in use all parts can be enclosed and out of the way in the streamlined cabinet which is readily portable on easy rolling casters. Overall size is only 14" x 12" x 25". Weight, 100 lbs. (60 cycle unit), 150 lbs. (25 cycles).

The brazer operates on 230 volt, 50-60 cycle power supply. 440 volt and 25 cycle units are also available. Rating is 7½ KVA. Secondary voltage is reduced to only 10 volts. Heating pliers have 6¼" long throat. Face of carbon is 1¾" x 2" but may be filed to shape best suited for a particular job.

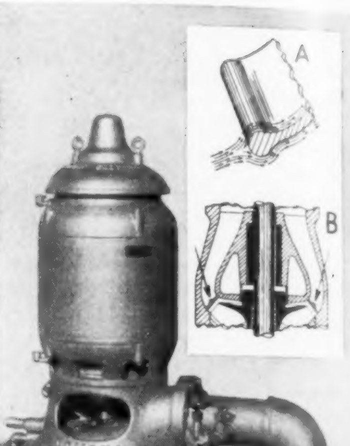
Uses for this tool are reported to be almost unlimited. Wherever soldered joints

are now made in motors, transformers, electrical leads, lugs and terminals, bus bars, automobile engines, aircraft engines, water heaters, fittings, carbide tool tips, band saws, etc., the brazer now makes possible the use of silver solder.

Vertical Turbine Pumps

The Pomona Pump Co., St. Louis, Mo., and Pomona, Calif., has recently been granted patents covering design improvements which eliminate hydraulic losses in pumps, thereby increasing efficiency as much as ten per cent. These improvements, now included in all sizes of Pomona Vertical Turbine Pumps, involve fundamental design changes in the guide vanes, function of which is to alter, from horizontal to vertical, the flow direction of fluids being pumped.

Previous practice in pump manufacture dictated that these guide vanes can be constructed as thin as possible on the advance edge, on the theory that the less metal the fluid would strike, the less would be the resistance encountered. However, it was discovered by Pomona engineers that, because fluid being discharged by the impeller element flows across the guide vanes at various angles (instead of always directly across the advance edge), eddy-friction losses are encountered, reducing the efficiency of the pump.



Typical Pomona Vertical Pump, equipped with new type guide vanes. Insert A: Bulbous shaped end of guide vane, showing even flow of fluid. Insert B: Cross-section of bowl assembly. Arrows indicate location of guide vanes.

By forming these advanced vane ends of a bulbous shape, it was discovered that regardless of the flow direction of the fluid, its direction would always be substantially tangential to the vane surface. Thus, greater uniformity of flow pattern is secured, friction is reduced and efficiency of fluid lift is increased. Furthermore, because of the recessive curve at the rear of the bulb-shaped vane, eddy currents are not developed as under former circumstances.

The improvement is inherent in the pump design, so that there are no gadgets or small parts to wear out. The new vane shape increases overall operating efficiency as much as ten per cent, with no increase in the original investment, and in addition permits the high efficiency to be maintained over a broader range of capacities than is possible with ordinary turbine pumps. Moreover the broader guide vanes give increased strength because of their extra thickness.

Inasmuch as the new guide vanes are an inherent part of the pump bowl assembly, it is not necessary for the owner of a vertical turbine pump to purchase a complete new pump in order to take advantage of the new design. It is only necessary to substitute a new bowl assembly. The manufacturer will be pleased to supply explanatory literature upon request.

Uniform Hardness by Abrasive Blasting

The Burgess-Norton Mfg. Co., Geneva, Ill., makers of automotive parts, screw machine products, and stampings installed a 27" x 36" Wheelabrator Tumblast, an airless abrasive blast tumbling type cleaning machine, several years ago for removing the scale from the holes of piston pins.

This company manufactures a great many piston pins for original equipment and the holes in the pins run from 1/4" to 2" in diameter with a corresponding variation in outer diameters and lengths. The removal of scale from the holes in the pins had always given them difficulty and they had

investigated various types of air sandblasting equipment, none of which seemed to meet their requirements.

Airless blast cleaning of the parts was suggested and a Wheelabrator Tumblast, after thorough investigation, was installed for their cleaning operations. In doing so they not only licked their problem, eliminated two very expensive grinding and lapping operations, but also discovered another advantage which was equally as important as the purpose for which the machine was originally purchased.

After the pins are cleaned in the Wheelabrator Tumblast, they are able to detect readily, any soft spotted condition—which condition is periodically prevalent in the making of piston pins since the great majority of them are made of low carbon steel, case hardened.

These soft spots will appear clearly in relief on the surface after Wheelabrating, by reason of the steel grit abrasive roughing up the surface of the soft spots to a considerably greater extent than the hard portion of the pin. This rougher surface gives the appearance of being a different shade of gray, thereby making the detection of the soft spots comparatively easy with the naked eye.

As a result of this detection of soft spots in the pins, the inspection of pins has become so simple and positive that the manufacturer can assure customers that the pins will be of uniform hardness throughout.

Technical Publications

Quenching Stresses in Aluminum. By Prof. Dr. A. von Zeerleder. Paper 87, Volume 67, 1941. Journal of the Institute of Metals, London.

A study has been made of the internal stresses in Avional D alloy set up by quenching, and of the possibility of eliminating them by subsequent cold work. The method used for determining the stresses consisted in measuring the dimensional changes of the stock during step-by-step removal of the outer layers. The variables studied were: time between solution treatment and quenching, temperature and nature of the quenching medium, temperature of aging and cold working before or after aging. The stresses are greatest on quenching in water at 20°C., and decrease as the temperature of the water is increased. They are small after quenching in oil, and are practically independent of its temperature. They are materially reduced or even reversed by cold working before or after aging.

Unsoundness in Gravity Die-Cast Silicon-Aluminium Alloy Pistons. By R. T. Parker. Paper 101, Volume 67, 1941. Journal of the Institute of Metals, London.

Unsound aluminum alloy pistons are examined by x-rays and the microscope and discussed.

The Corrosion of Copper and Some Copper Alloys in Atmospheres Highly Polluted with Coal Smoke. By S. C. Britton. Paper 119, Volume 67, 1941. Journal of the Institute of Metals, London.

A paper giving photomicrographs and discussion of the results of corrosion tests on various copper alloys after exposure in railway tunnels for three and a quarter years.

Manufacturers' Literature

Bandsander

A 4-page folder recently published by *Mead Specialties Co.*, 15 S. Market St., Chicago, Ill., describes and illustrates the construction and various uses for the company's bandsander. This sander is designed for carving, shaping and polishing of wood, plastics and metal objects. Photographs illustrate the specific use of the sander for various operations.

Brazing Tool

Ideal Commutator Dresser Co., Sycamore, Ill., describe their new electrical brazing tool in a recently issued folder. The brazer enables silver soldering of all types of metals without pre-heating. The work is held in special heating pliers and quickly brought to silver soldering temperature inasmuch as heat is concentrated on the exact spot where needed. Various applications for this brazing tool are described.

Copper Plating Process

United Chromium, Inc., 51 E. 42nd St., New York, have just issued a 4-page leaflet describing the company's new "Unichrome Alkaline Copper Plating Process," discussing the type of plating bath, operating cycle and equipment used as well as

the time and labor-saving features of this process. With this process, smooth fine-grained deposits are claimed possible to thicknesses of 0.001" or more. They buff easily and no special cleaning or activation is required for subsequent plating.

Temperature Control for Pickling

The Foxboro Co., Foxboro, Mass., have issued a 4-page illustrated folder describing both air-operated and electrically operated controls for pickling tanks. Drawings illustrating the use of these controls as well as photographs of the controls are given in the literature.

Pickle Control

A new 12-page booklet concisely describing how certain recently developed materials provide several improvements from both results and costs standpoints in production pickling and neutralizing operations, has just been issued by *Oakite Products, Inc.*, 18 Thames Street, New York.

In addition to presenting formulas and charts covering the use of Oakite Pickle Control as an acid inhibitor and its advantages in reducing hydrogen embrittlement, preventing over-pickling and reducing acid fumes, the booklet also gives detailed data on other Oakite materials for neutralizing.

Porous Bearings

A revised catalog listing additions to their line of "Selflube" porous bearings has just been issued by Keystone Carbon Co., 1935 State St., St. Marys, Pa.

The new catalog describes the properties and uses of these self-lubricating bearings and furnishes complete details on the correct method of installation. Many different shapes of the porous bearings are illustrated. Standard sizes for plain bearings, flanged bearings, and thrust bearings, are listed. The last two pages contain graphs showing the allowance on "Selflube" bearings for press fit into housing, and the allowance for running fit after installation.

Stair Treads and Floor Tile

National Bronze & Aluminum Fdy. Company, E. 88th St. and Laisy Ave., Cleveland, Ohio, describe and illustrate their "Ten-Lox" anti-slip stair treads and floor tile, which is stated to be an aluminum casting impregnated with abrasive. This material is said to give durable and permanent anti-slip characteristics when dry, wet with oil or with water. Specifications are given and typical applications are illustrated.

New Books

The Analytical Chemistry of Industrial Poisons, Hazards and Solvents. By Morris B. Jacobs. Size 9½" x 6½"; 615 pages. Price $7.00. Published by Interscience Publishers, Inc., New York, N. Y.

This book will make a welcome addition to the not too voluminous literature of chemical aspects in industrial hygiene.

In the introduction, the historical background of industrial hygiene is discussed, and industrial hazards and poisons are classified. A considerable portion of the book is devoted to methods of sampling and analysis of the atmosphere. The equipment used is discussed in detail and numerous illustrations amplify the discussion.

A chapter is devoted to velocity gas measurement instruments, and another to absorbers and absorbents. Chemical and microscopic estimation of various dusts are considered at length. The usual treatment is to give a general discussion of the toxic substances and then the physiological response and toxicity are discussed in detail. Following this, methods of detection and determination are discussed in detail. Frequently, special alternative methods of analysis are given. Some of the substances treated in this book are the dangerous metals, such as lead, mercury and arsenic and other harmful metals, poisonous compounds of sulphur, phosphorous and nitrogen. The poisonous compounds of the halogens and various organic compounds, such as hydrocarbons, halogenated hydrocarbons, alcohols, aldehydes, ketones and acids.

A chapter is devoted to chemical warfare agents and in the appendix valuable tables are given on the limits of inflammability and explosive range and physiological safe and harmful limits.

The book contains a great deal of information which should be of value to those not engaged in the analytical chemistry of industrial poisons and, of course, the book should prove to be a valuable reference in the analysis of substances contributing to industrial hazards.

Index to the Literature on Spectrochemical Analysis

A 50 per cent increase in the number of references has been made in this Index since its first publication in 1937. The second

edition contains 1467 references, many of the recently added ones cover improved descriptions of atomic spectra, studies of light sources and calibration processes, and conditions influencing the accuracy of quantitative determinations.

All workers concerned with this field will find this Index of invaluable assistance to them in locating the voluminous and far-flung literature on the subject.

Copies of the 96 paged, 6 by 9 in., "Index to the Literature on Spectrochemical Analysis" (Second Edition) can be obtained from the American Society for Testing Materials, 260 S. Broad St., Philadelphia, Pa., at $1.00 per copy.

Communications

On the Determination of the Thickness of Chromium Plate

CRANE CO.
ENGINEERING AND RESEARCH DIVISION
4100 *So. Kedzie Ave.*
Chicago

June 27, 1941.

Dr. Walter R. Meyer
Editor, METAL FINISHING
116 John Street
New York City

Dear Dr. Meyer:

Since the presentation of the electrolytic tester for chromium plating thickness*, there has come to my attention some evidence of skepticism as to the accuracy of our calibration in comparison with the hydrochloric acid spot test. As noted in our paper we found that our local tester gave readings which averaged 10% higher than those obtained by us with the hydrochloric acid test. Since that data were obtained, Blum and Olson** have presented a new calibration for the acid spot test, the effect of which would be to indicate that our tester readings were 15% lower than the acid test on the basis of the new calibration.

Thickness specifications customarily accept the microscopic method as an umpire test, but since the thickness of decorative chromium plating is of the order of a wave-length of light or less, it is physically impossible to obtain a microscope using visible light to resolve sufficiently precisely for umpire testing. However, even more basic than the microscope scale is the length scale provided by monochromatic light waves by means of which precision gage blocks are calibrated and the international meter measured. Our work included calibration based directly on the wave-length of the 5461 A mercury line, which agreed within experimental error with our other data.

During the past month I have re-investigated our calibration by measuring the weight gain of four separate nickel foils due to chromium electrodeposited uniformly thereupon by the method described in our paper. In order to evaluate the effect of the plating solution upon the nickel sheets, two blanks were run which showed the error to be less than 3% of the weight deposited. Actual weighings were made by Dr. Ma of the Micro-analytical Laboratory of the University of Chicago. Thickness determinations obtained varied —2.8%, 0%, —4.5% and —2.4% from the average of four electrolytic readings (as previously calibrated) on each specimen.

I believe others should be encouraged to trace down this apparent discrepancy between the two tests. My own skill with the acid spot test is admittedly more limited than it should be.

Very truly yours,
STANLEY ANDERSON
Research Physicist
Research and Development Laboratories

* Transactions of the Electrochemical Society, October, 1940.
** Proceedings of the American Electroplaters' Society, 1940.

Associations and Societies

American Electroplaters' Society

Los Angeles

Los Angeles Branch, A.E.S., held its annual picnic in City Park, Montebello, Calif., on Sunday July 20. A picnic lunch, served under vinegrown pagodas, constituted

the feature of the forenoon program. Coffee, ice cream, soda pop and watermelon were served with the compliments of the branch.

Bruno H. Schindler acted as chairman of the Coffee Pot Committee and dispensed his fragrant collations in the efficient manner that has earned him permanent chairmanship of this committee. The branch discovered hitherto latent talents in Librarian *Emmette Holman*, who disclosed himself as a veritable artist in carving watermelon in his capacity as chairman of the watermelon committee. Sergeant-at-arms *Carroll McLaren* and President *Don Bedwell* served indiscriminately as chairman and co-chairman, respectively, of the soda pop committee, retrievers of footwear in the shoe-kicking contest, and as judges in the pie-eating event.

The greater part of the afternoon was devoted to a variety of games and races in which men, women, boys and girls participated.

The three-legged race for men was won by *Gene Rynkofs* and *Lester Belger* who, by virtue of their victory of this race in 1940 now claim to have "two legs on the three-legged race trophy." (Author of that pun was Lester). Second place in this event went to *H. Covey* and *R. Ellis*, and third place to *Don Bedwell* who teamed up with *Ray Vasquez*.

Sherrill Martinson and *Eleanor Oliphant* won the three-legged race for women. *Mrs. Ruth Belger* and *Mrs. Rene Herbst* were second, and *E. W. Francis*' charming daughter *Jean* and *Doris Richardson* hop-footed into the finish line for third prize, barely nudging out *Mrs. Ray Vasquez* and *Betty Foote*.

The picnic committee consisted of *E. R. Cahoe, Charles Russell, Clarence Thornton, Ray Vasquez, Erwin Frauenhoff, D. N. Eldred, Gilbert Bishop, Stanley Rynkofs, Bruno H. Schindler, Emmette R. Holman*, and *Earl Coffin*.

Electrochemical Society

Preliminary Program for the 80th Meeting of The Electrochemical Society, Inc.

HOTEL KNICKERBOCKER
CHICAGO, ILLINOIS
OCTOBER 1-2-3-4, 1941

Industrial Electrochemical and Educational Exhibits will be open to all attending throughout the meeting. The Oceanic Room, on the Convention Floor, has been reserved exclusively for these exhibits.

LADIES' PROGRAM. The Ladies will find Chicago hospitable and the Ladies' program just what they might hope for.

★ ***Wednesday, October 1st***

Registration in Lobby
Board of Directors Meeting
General Business Meeting

★ ***Thursday, October 2nd***
A.M.

Group Breakfasts
Registration (Cont'd.) Convention Floor
Electroplating Technical Session Four Papers

1. General Principles and Methods of Electroplating
   Blum, Beckman, and Meyer
2. Alloy Plating, *Faust*
3. Rare Metal Plating, *Kushner*
4. Lead Plating, *Blum*

Noon

Group Luncheon

P.M.

Electro-organic Technical Session

Technical Papers and Discussion

★ ***Friday, October 3rd***

A.M.

Group Breakfasts

Registration (Cont'd.) Convention Floor

General Technical Session

1. Mercury-Mercurous Iodate Electrode (in two parts), *Haring* and *Zapponi*
2. Potassium Permanganate by Anodic Dissolution of Ferro-Manganate, *Lowy*
3. Electrophoretic Filtration of a Kaolin Slurry, *Ralston* and *Hoseh*
4. Electrolyte Films, *Read* and *Graham*
5. Activation of Ammonia Synthesis, *Glockler* and *Loeppert*
6. X-Ray Examination of SiO, *Baumann*
7. Solvent Effect on Semi-Quinone Equilibria, *Burstein* and *Davidson*

Noon

Group Luncheon

P.M.

Electroplating Technical Session

Six Papers

1. Acid Zinc Plating, *Lyons*
2. Cyanide Zinc Plating, *Hull* and *Wernlund*
3. Cadmium Plating, *Westbrook* and *Soderberg*
4. Brass and Bronze Plating, *Coats*
5. Silver Plating, *Promisel* and *Wood*
6. Iron Plating, *Thomas*

Adjournment followed by dinner in the Ballroom and talk on chemurgy by *Dr. Wm. J. Hale*

★ ***Saturday, October 4th***

P.M.

Electroplating Technical Session

Seven Papers

1. Rochelle Copper Plating, *Graham* and *Read*
2. High Speed Copper Plating, *Wernlund*
3. Acid Copper Plating, *Winkler*
4. Nickel Plating, *Pinner, Soderberg,* and *Baker*
5. Chromium Plating, *Dubpernell*
6. Alkaline Tin Plating, *Oplinger* and *Bauch*
7. Acid Tin Plating, *Pine*

Electropolishing Stainless Steel In Phosphoric-Sulfuric Acid Baths†

Charles L. Faust and H. A. Pray

The paper describes commercially operable methods for electropolishing stainless steel. Formed or cast articles previously left unfinished because of complex shape or extreme surface roughness can now receive a "finished" or "quality" appearance, ranging from satin, to bright frosty, to mirror brilliance. Electropolishing is a finishing process for which the results must be evaluated on their own merits. In some applications the mechanical and electrolytic finishing will overlap, but in other cases one or the other alone will be the more suitable.

In general, the polishing baths contain 50% or more of total acid concentration with 5 to 85% H_2SO_4, 5 to 85% H_3PO_4 and up to 20% CrO_3. Certain preferred bath compositions are discussed. The bath is selected according to the throwing power requirement; the composition of the stainless steel; and the results desired.

The limits of variation of each operating factor are broad enough for ready control in the plant, yet there are definite ranges that must be maintained. Electropolishing is accomplished at the practical current densities of 70 to 500 amp./ft.^{2} and temperature of 100° to 200° F. according to bath and stainless steel compositions. Agitation is beneficial.

The throwing power of electropolishing is better than that of acid electroplating baths such as those for nickel, zinc, copper, chromium, etc. Economical electropolishing times are in the range of 1 to 15 minutes. The life of the baths depends on the metal dissolved from the work.

Tank setups are not complicated and special materials are not required. Tanks are lead lined. Cooling or heating coils, exchangers, etc., are also of lead. Cathodes consist of lead sheets or strips hung from bus bars. Racks are made of copper and may be used bare, but are preferably coated with any one of several commercial materials. Contact points on the racks are lead or solder coated and are not attacked by the electropolishing bath. Corrosive gases are not emitted. Under some operating conditions a small amount of spray might require removal by equipment such as used in chromium plating.

†Abstract of paper presented at 29th Annual Convention American Electroplaters' Soc., Boston, Mass., and not abstracted in July issue.

Business Items

New Plant for Sparkler Manufacturing Company

Steadily increasing sales of their horizontal-plate filters have made it necessary for the *Sparkler Manufacturing Company*, Chicago, to expand their production facilities in new larger quarters, according to an announcement just made by *A. C. Kracklauer*, president of the company.

After August 1, the Sparkler organization will be located in their own factory at Mundelein, Illinois. The building is on U. S. highway No. 45 and provides approximately 10,000 square feet of floor space for manufacturing operations. The new set-up, it is stated, gives the company a production area twice that of its former plant at 1210 Webster avenue, Chicago.

C. J. Sommers and *L. G. Sommers* have formed the *Sommers Bros. Mfg. Company*, with address at 3439-43 N. Broadway, St. Louis, Mo. This company will engage in the manufacture of plating and polishing supplies and equipment. C. J. Sommers was formerly sales representative of the Lustre Company, St. Louis, and covered seven states, as well as the city of St. Louis. In addition, he had charge of most of the technical matters pertaining to the business. L. G. Sommers was in charge of the manufacturing end of the Lustre Company's business. The brothers have had 21 years' experience in the plating supply business.

The Magnuson Products Corp. announce the removal of their main offices, from the plant at Hoyt & Third Sts., Brooklyn, N. Y., to 50 Court St. in the Terminal Building. Here their large suite of attractive offices occupy a major part of the eighth floor.

Edward Magnuson, president of the corporation, states that this change has become necessary owing to the steady expansion of the business, and which naturally necessitated more room for manufacturing and future development of the company's cleaning compounds.

The Magnuson Products Corp. was established by Mr. Magnuson in 1923 in Brooklyn and the growth of the concern has been constant and successful.

Philadelphia Quartz Company Celebrates 110th Birthday

When, on July 20, 1831, Joseph Elkinton closed up his Philadelphia shop at the end of his first day in the soap and candle business, he probably never gave a thought to the enterprise that his descendants would be operating 110 years later as the Philadelphia Quartz Company. More than likely his reminiscences that evening in his family group were of his missionary service for the previous 15 years to the Society of

Friends among the Tunessassa Indians of New York.

The soap kettles in the rear of Joseph Elkinton's dwelling supplied the bars of soap for the store in front for retail trade but the bars of "Family Soap" were to be known and distributed more widely, finding their way to the South, West, North, and along the coast to foreign lands by packet and brig.

After his sons, Joseph S. and Thomas, had finished their schooling they took an active interest in the soap factory. The young brothers had a deep concern about new developments and improvements in the soap field. It was Thomas who investigated soluble glass. Early in 1858 equipment was bought for experimenting with silicate of soda.

In the '60s, the war between the states caused curtailment in rosin supplies from the South. Other soap materials also soared in price. Soluble glass was mixed with the soap as a substitute for the rosin and was found successful. Thus Joseph Elkinton and his sons had developed at just the right time a detergent which could be offered at a reasonable price to replace other ingredients then unattainable. The new soaps found favor with their customers and other soap makers came to the Elkintons for supplies of silicate of soda as well as instructions on how to use it in their formulae.

Then began a company tradition which at that time was unusual, that of giving information and assistance to the user which enabled him to obtain maximum benefits from the products. The forerunner of a series of comprehensive educational bulletins was published shortly after 1864. Then silicate of soda was tried for other things and ever since this blazing of new-use trails has been constant. The adhesive value of silicate of soda was early discovered, but it was not until the introduction of the corrugated shipping box in the '90s that there was a larger demand for silicate as an adhesive. Research of the company over a long period has developed a series of chemicals made by varying the proportions of the ingredients of silicate of soda. Now from the one solution originally produced, the company's catalog includes over 33 different silicates.

From the diary of Joseph S. Elkinton, we find record in the first month, 1862, of the father withdrawing his name from the firm and leaving the conduct of the business to his sons under the name of Joseph S. & Thomas Elkinton. The present name, Philadelphia Quartz Company, was used in 1864 when a partnership was formed to manufacture the new chemical silicate of soda. Soap manufacture was discontinued in 1904 when the Philadelphia Quartz Company was incorporated.

About the time of the celebration of the company's beginning of another century in business came the announcement of two new alkalis, previously not commercially obtainable. These chemicals, sodium metasilicate and sodium sesquisilicate made available to industries alkaline cleaners which had active alkali qualities but which were controlled by silica content.

The company reached the threshold of a second century under the direction of only the third generation of the family of the founder. William T. Elkinton, son of Joseph S. Elkinton, continued the head of the enterprise until his death in October, 1933. He had devoted more than 50 years to the building of the business and several years prior to his passing planned a gradual retirement that others might learn to carry on. His son, Thomas W. Elkinton is now president of the company.

The Philadelphia Quartz Company, with general offices in Philadelphia, today has nine plants, located at Chester, Pa., Anderson, Ind., Baltimore, Md., Buffalo, N. Y., Kansas City, Kans., Rahway, N. J., St. Louis, Mo., Utica, Ill., Jeffersonville, Ind., and is affiliated with Philadelphia Quartz Company of California, Ltd. who operates plants at Berkeley and Los Angeles.

Recent additions to the staff of *Foster D. Snell, Inc.*, include:

John A. Casey, B.A., Brooklyn College.

R. Neil Dalton, B.S., Brooklyn Polytechnic Institute.

John Mandel, graduate of the University of Brussels (Belgium).

William A. Rassiga, B.S., College of the City of New York; M.A., Columbia University.

Norton Company, Worcester, Mass., manufacturers of grinding machines, grinding wheels and other abrasive products, has announced the appointment of *Paul Fielden* director of purchases. Mr. Fielden has been connected with the company 21 years as assistant credit manager and credit manager. He has been prominent in local and national credit men's associations and in 1937-1938 was president of the National Association of Credit Men.

John Miller, for a number of years assistant credit manager of Norton Company, succeeds Mr. Fielden as credit manager.

Marcus W. White retains the position of purchasing agent, which he has held with the company for many years.

Foxboro Company Adds to New England Sales Force

The extraordinary industrial activity in New England has greatly increased the demands upon the sales engineers of *The Foxboro Company* and has resulted in recent additions to the force. *Elmer E. Forslind*, a graduate of Northeastern University and for several years in various branches of public utility engineering, has joined The Foxboro Company and will be attached to the New England Office, at Foxboro, Mass. *William Wallace Nelson* who, for the past four years has been a Foxboro service engineer, has been transferred to the New England sales force. Mr. Nelson is a graduate of Tufts College, with special engineering training from Boston University.

Day-Ray Products, 912 Fair Oaks Ave., South Pasadena, Calif., has completed installation of equipment for the manufacture of fluorescent inspection and work lights, and various auxiliary units.

Electrical Research & Manufacturing Co., a division of *U. S. Hardware Co.*, has been established at 3001 East Pico Blvd., Los Angeles, to manufacture electrical appliances, such as toasters, flat irons and mixers. The company will also go in production of airplane parts, electric wiring assemblies as well as doing miscellaneous small machine work. *O. S. Brandeis* is vice-president and general manager.

Conmar Products Corp. of Newark, N. J., has taken manufacturing space at 860 South Los Angeles St., Los Angeles, for the processing of slide fasteners for the west coast market. The fasteners will be shipped to Los Angeles in long lengths from the Newark factory for cutting up and fabrication into necessary fittings in the Southern California plant.

Alemite Co., of Southern California moved July 1 from 1220 South Hope St. to 33 West Washington Blvd., Los Angeles, where 15,000 square feet of floor area are available for the distribution of automotive supplies as well as the local manufacture of air and water pressure gauges, speedometers and tachometers.

Rinolite Co., Los Angeles, has removed to new quarters at 645 Imperial St., Los Angeles, where enlarged facilities and floor area are available for carrying on enameling operations in connection with kitchen and bathroom products.

Norris Stamping & Manufacturing Co., whose main plant and headquarters are at 960 East 61st St., Los Angeles, has completed a new 130 by 170 foot addition to its branch factory at 521 Boyle Ave., Los Angeles.

Western Galvanizing Co. has construction under way on a new building with 5,000 square feet of floor area at 2554 East 25th St., Los Angeles.

The Foxboro Company, makers of industrial instruments, announces that *Paul T. Graff* has joined its staff as a sales engineer, specializing in the promotion of the company's control instrumentation. He will be located at the company's main office, at Foxboro, Mass. To his new work Mr. Graff brings the benefit of broad experience in the oil refining industry and other fields in which instrumentation is extensively employed. He is a graduate of the Harvard Engineering School.

The appointment of *W. A. Fletcher* as District Sales Manager for the Western Division of *E. F. Houghton & Co.*, manufacturers of oils, leathers and metal working products, Philadelphia, is announced.

Mr. Fletcher will maintain his headquarters at 835 Harrison Street, San Francisco, and will be in charge of sales in California, Oregon and Washington. He has had a long record with this company, having formerly been District Sales Manager in Cleveland and more recently head of their Government Products Division.

Recent changes in the *Handy & Harman* organization have brought *J. W. Colgan*, formerly manager of Handy & Harman of Canada Ltd., Toronto, back to New York in the capacity of Sales Manager of the parent company. Jack, as so many know him, is not a stranger to the trade in this country, having seen 17 years of service in the New York sales department before going to Toronto five years ago. He is taking charge of all company sales work connected with the silversmith and jewelry industries, as well as the growing industrial work in which the company is now engaged.

Supply Prices, July 25, 1941

Anodes

Prices are f.o.b. shipping point on quantities of from 500-999 lbs. for copper, brass and zinc. For nickel, prices are for quantities from 500-2,999 lbs.

COPPER: Cast, elliptical, 15" and longer	.25⅛c. per lb.
Electrolytic, full size, .22⅞c; cut to size	.22⅞c. per lb.
Rolled, oval, straight 15" and longer .23¼c. per lb.; curved	.24¼c. per lb.
BRASS: Cast, 80-20, elliptical, 15" and longer	.23⅝c. per lb.
ZINC: Cast, 99.99, 16" and over	15¼c. per lb.
NICKEL: 95-97 cast, elliptical 46c. per lb., 99% plus cast 47c.; Rolled, depolarized	48c. per lb.
SILVER: Rolled, .999 fine per Troy oz.	38c. per oz.

Chemicals

These are manufacturers' quantity prices and based on delivery from New York City.

Acetone, C.P., drums, l.c.l.	lb.	.09
Acid, Boric tech., 99.5% gran., bbls.	lb.	.0615
Chromic, 99%, 100 lb. drums, l.c.l.	lb.	.18¼
Hydrochloric (muriatic) Tech., 20°, carboys, wks.	lb.	.0270
Hydrochloric, C.P., 20°, bottles	lb.	.19
Hydrofluoric, 30% bbls.	lb.	.06-.06½
Nitric, 36°, carboys 1-9, wks.	lb.	.0595
Nitric, 42°, carboys 1-9, wks.	lb.	.0745
Oleic (Red Oil), distilled, drums	lb.	.12½
Oxalic, bbls. l.c.l.	lb.	.14
Stearic, distilled, double pressed, bags	lb.	.13¾-.14¾
single pressed, bags	lb.	.13¼-.14¼
triple pressed, bags	lb.	.16½-.17½
Sulphuric, 66°, carboys 1-9, wks.	lb.	.0245
Alcohol, Amyl, (Fusel oil, ref'd), l.c.l., drums	lb.	.17½-.19½
Butyl-normal, l.c.l., drums	lb.	.11½
Denat., S.D. #1, 190 pf., 1-18 drms, wks.	gal.	.35
Diacetone, tech., drums, l.c.l.	lb.	.12-.12½
Methyl, (Methanol), 95%, drums, l.c.l.	gal.	.48½
Propyl-Iso, 99%, drums, l.c.l.	gal.	.43-.47
Propyl-Normal, drums, wks.	gal.	.70
Alum, ammonia, granular, bbls., works	lb.	.035
Potash, granular, bbls., works	lb.	.0375
Ammonia, aqua, 26°, carboys	lb.	.05¼
Ammonium, chloride (sal-ammoniac), white, granular, bbls., wks.	lb.	.0445
Sulphocyanide (thiocyanate), pure, crystal, kegs	lb.	.65
Sulphocyanide (thiocyanate), tech., kegs	lb.	.40
Antimony Chloride (butter of antimony), sol., carboys	lb.	.17
Barium Carbonate, ppted., bags, l.c.l., works	lb.	.026
Benzene (Benzol), 90%, drums, works	gal.	.19
Butyl Lactate, drums	lb.	.235
Cadmium Oxide, l.c.l., bbls.	lb.	.95
Calcium Carbonate (Ppted. chalk), c.l., wks.	lb.	.02¾
Carbon Bisulfide, l.c.l., 55 gal. drums	lb.	.05¾
Carbon Tetrachloride, l.c.l., drums	gal.	.73
Chromic Sulphate, scale, 100 lb. drums	lb.	.45
Cobalt Sulphate, drums	lb.	.71
Copper, Acetate (verdigris), bbls.	lb.	.26
Carbonate, 52-54%, bbls.	lb.	.16½
Cyanide, Tech., 100 lb. bbls.	lb.	.34
Sulphate, 99%, crystals, bbls., 1-5	lb.	.0535
Cream of Tartar (potassium bitartrate), gran., kegs	lb.	.53½
Crocus Martis (iron oxide) red, bbls.	lb.	.03¼
Dibutyl Phthalate, drums, l.c.l.	lb.	.195-.205
Diethylene Glycol, drums, l.c.l., works	lb.	.155
Dextrin, white, bags, F.O.B. Chicago	lb.	.0395
Emery (Turkish)	lb.	.08
Ethyl Acetate, 85%, l.c.l., drums, works	lb.	.085
Ethylene Glycol, l.c.l., drums, works	lb.	.15½-.18½
Monoethyl ether, dms., l.c.l., wks.	lb.	.125-.155
Gold, Chloride, yellow, bottles	oz.	$19.25
Cyanide, potassium 41%, bottles, wks.	oz.	$14.20-$14.95
Gum, Arabic, white, powder, bbls.	lb.	.21-.22
Hydrogen Peroxide, 100 volume, carboys	lb.	.16-.18½
Iron Sulphate (Copperas), cryst., bbls., 1-4 wks.	lb.	.02
Lead, Acetate (Sugar of Lead), crystals, bbls.	lb.	.12½
Oxide (Litharge), com., powdered, bbls.	lb.	.08¼
Magnesium Sulphate (Epsom Salts), tech., bbls.	lb.	.018
Mercury Bichloride (Corrosive Sublimate), crys.	lb.	$2.39
Mercuric Oxide, tech., red, powder, bbls.	lb.	$3.11
Nickel, Carbonate, dry, bbls.	lb.	.36-.36½
Chloride, bbls.	lb.	.18-.20
Salts, single, 425 lb. bbls.	lb.	.135-.145
Salts, double, 425 lb. bbls.	lb.	.135-.145
Paraffin, refined, bgs., 123-125 a.m.p., c.l.	lb.	.057
Perchlorethylene, drums, l.c.l.	lb.	.08½
Phosphorus, red, cases	lb.	.44
yellow, cases	lb.	.23-.25
Potash, Caustic, 88-92%, flake, drums, works, c.l.,	lb.	.07
Potassium, Bichromate, crystals, casks	lb.	.10
Carbonate (potash) calc., wks. drums		.06¾
Cyanide, 94-96%, dom. dms., wks.	lb.	.55
Pumice, ground, 1½ F. & coarser, bbls., wks.	lb.	No price
Quicksilver (Mercury), dom. 76 lb. flasks, net	flask	$192.
Rochelle Salts, crystals, bbls.	lb.	.40
Rosin, gum, B, bbls., dock	lb.	.0294
Silver, Chloride, dry, 50 oz. lots	oz.	.37½
Cyanide, 100 oz. lots	oz.	.33¾
Nitrate, 100 oz. lots	oz.	.24
Sodium, Carb. (soda ash), light, 58%, bags	lb.	.0208
Cyanide, 96%, dom. 100 lb. drums	lb.	.15
Hydroxide (caustic soda) 76%, flake, l.c.l.	lb.	.0490
Hyposulphite, crystals, bags, wks.	lb.	.0250
Metasilicate, granular, 1-9 bbls.	lb.	.0335
Nitrate, rfd., gran., bbls., wks.	lb.	.029
Phosphate, tribasic, tech., bbls., wks.	lb.	.0295
Pyrophosphate, anhydrous, bags, l.c.l.	lb.	.0560
Sesquisilicate, 1-9 drums	lb.	.0425
Stannate, drums	lb.	.0375
Sulphate, anhydrous, bbls., works	lb.	.0215
Sulphocyanide, drums	lb.	.28-.47
Sulphur, Flowers, U.S.P., bbls., l.c.l. mine	lb,	.0335
Tin Chloride, crystals, kgs.	lb.	.40-.40½
Toluene (Toluol), 2°, ind., drums, works	gal.	.32
Trichlorethylene, drums, l.c.l., zone 1	lb.	.08½
Tripoli, air floated, bgs., c.l., wks.	ton	$26.00
Wax, Bees, white, bleached, slabs, 1-5 cases	lb.	.47-.50
Bees, yellow, crude, Brazil, 100 lbs.	lb.	No stocks
Carnauba, refined, bags	lb.	.82
Montan, bags	lb.	No prices
Spermaceti, blocks	lb.	.24-.25
Whiting, precipitated, bags, l.c.l.	ton	$20.00
Xylene (Xylol), ind., returnable drums, works	gal.	.31
Zinc, carbonate, tech., bbls.	lb.	.20
Cyanide, 100 lb. kegs	lb.	.33
Chloride, tech., granular, drums, c.l., wks.	lb.	.05
Sulphate, crystals, bbls., l.c.l.	lb.	.039

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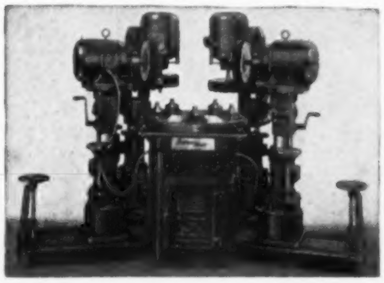

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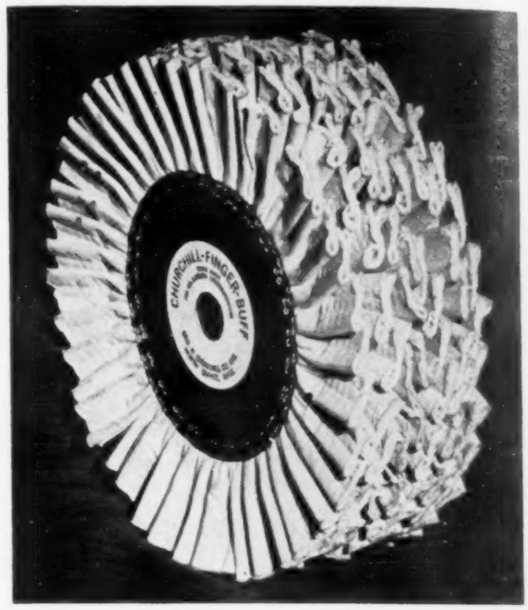

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Try a set for FASTER Production and LOWER COSTS

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Methods described in nine bright-plating patents issued in the past few years had been tried previous to 1936 and considered unworthy by the makers of

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